Second Revised Edition

The Compact Lathe

STAN BRAY

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THE COMPACT LATHE

Stan Bray

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INTRODUCTION

What is a compact lathe? Strictly speaking, there is no one definition, but basically we use the term to describe the sort of lathe that is easily portable. So portable, in fact, that it can be picked up and put away when one is finished with it. I know of people who, as well as putting such a lathe away when they are not using it, also take it away on business with them and use it wherever they are staying.

Small lathes are certainly not a new innovation. There have been specialist watch and clockmaking machines available for many years, but these high-precision, very expensive machines are not included within the scope of this book. Over the years, there have also been many small lathes of the type now referred to as 'compacts'. These have all gradually disappeared. Why was this? I believe the reason is that they were usually made as direct copies of larger models but reduced in size. Most were marketed by small businesses. There was then a two-fold effect. The lathe design itself, while suitable for a larger model, was not right for a small lathe and so they were difficult to use. There were also very few accessories made for them with the result that they were very limited in their scope and not popular. Also, the firms marketing them were small, often single-person businesses and, when the owner sold out or ceased trading the lathe was no longer marketed. Nowadays, many of the compact lathes are marketed by big multinational companies, and are sold not just in Britain but all over the world. There are also so many extras available that the lathes are capable of tackling much more than the older models. For some time now the market has been very stable and the only visible changes are gradual improvements to the models.

These days the compact lathe can be a very sophisticated machine. It can be capable of carrying out all the functions we would expect to get from a much larger lathe, although it must be said that it will obviously not be capable of working to such

large dimensions. I will give examples of the uses to which such machines can be put and what can be made on them. Today, most are also quite capable of carrying out milling operations as well as screw cutting, so we have a virtually complete workshop in one compact area.

Being small, the lathes generally work out cheaper than the larger models. For this reason, they can be an ideal starting point for a beginner and, in particular, they are the ideal machine for a youngster to learn machining skills with.

I would like to thank most sincerely the suppliers and manufacturers who kindly gave me the information I required as well as, in some cases, the loan of a machine. Without their help this book would not have been possible.

PART 1

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1 SAFETY

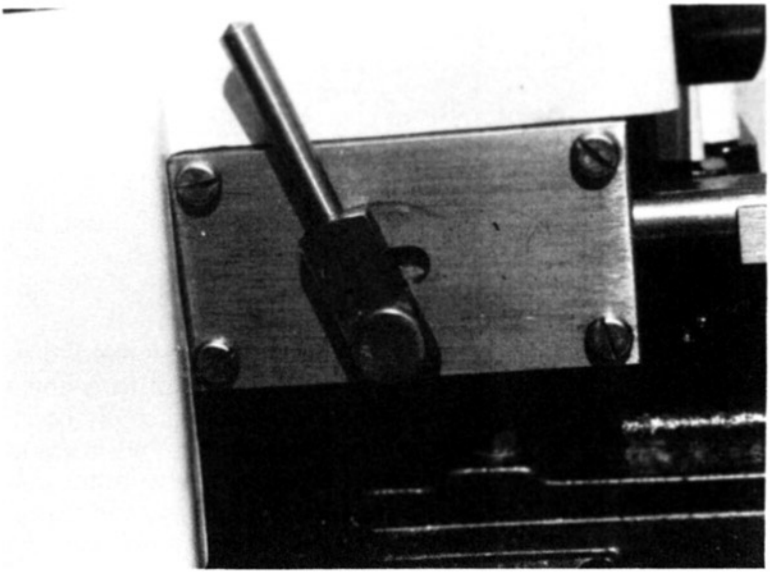
In industry today, there are many safety rules that need to be observed by the centre lathe operator. It is doubtful if any home machinist using a compact lathe follows such a safety code, and it is equally doubtful if there is any need to. This is not to say that safety methods should not be adopted, rather that there is no need to go to the same lengths of those in industry.

The most important safety rule is to use common sense, and that really is all that safe working amounts to. We must use common sense to ensure that we do not catch our hands on revolving tools such as milling cutters and drills. To do so would inevitably result in nasty cuts and, with the oil and swarf found on the lathe, there is every danger of wounds turning septic. Once a lathe has started revolving, then keep hands well away from it and wait until the machine has stopped before putting them anywhere near it. The fitting of some form of simple guard to the lathe, drilling or milling machine is advisable. A simple home-made device is quite sufficient.

The revolving chuck on a compact lathe does not, as a rule, have the tremendous power found on larger lathes. Even so, we are used to thinking in terms of motors of a quarter of a horse power, which is fairly powerful. From experience, I can assure readers that catching one's hand between the revolving chuck and the saddle or cross slide is a very painful experience indeed, and can even cause enough damage for hospital treatment to be needed. Even with less powerful motors, a very nasty injury can be received, so here again caution and common sense are needed to ensure that fingers are kept away from the chucks when the machine is in operation.

The use of safety glasses should be normal practice. These are very cheap and can prevent metal chips getting into the eyes.

Loose sleeves can be a problem and, as well as catching in revolving machinery, they can, on some machines, catch on



If sleeves are left loose there is a danger that they will catch on switches such as this and switch machinery on without the knowledge of the operator.

switches and turn the machine on while setting up operations are being carried out. Buttoned sleeves or an elastic band round the wrist are simple precautions and, once again, can save a very nasty injury.

Wear shoes when using the lathe. Soft slippers or open sandals are asking for trouble. Any tool falling from the lathe or bench will inevitably land cutting edge down when falling on an unprotected foot.

If you are a sufferer from skin disease, then consider the use of a barrier cream before using the machine. In particular, some cutting oils can cause irritation of the skin, and a waterproof barrier cream will prevent any complications of this type. These creams also make it easier to clean up after work, and that is also a very good reason for using them.

Check thoroughly all electrical equipment from time to time. Wires do work loose in plugs and can be the cause of severe electric shocks. The fitting of an automatic circuit breaker is advised, as this should switch off before the current can reach the operator if any mishap occurs.

None of the above suggestions involves any great hardship or expense and, as I said at the beginning of the chapter, are all just a matter of common sense. Think safety and be safe.

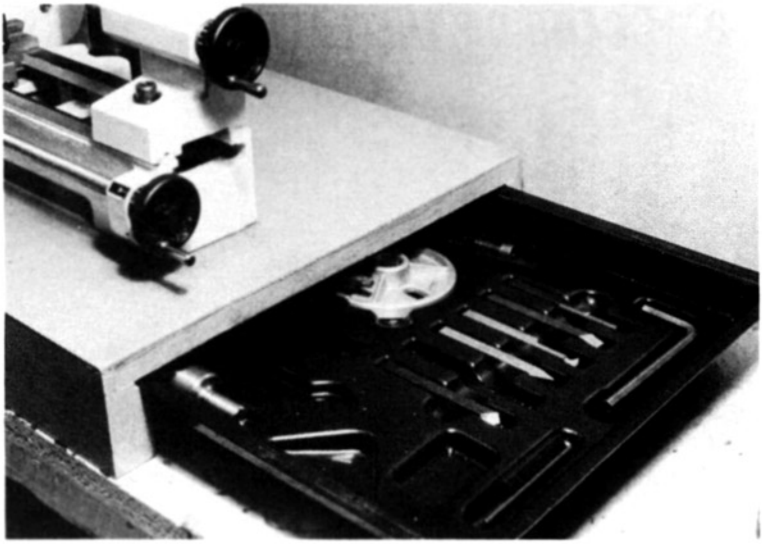
2 CARE OF THE LATHE

Cleanliness is essential if we are to take care of our lathe. After use, it should always be cleaned with a soft rag, and a fine brush used to remove swarf and dirt which may have gathered in crevices. It is particularly important to clean off the residue of any cutting fluids that may have been used. These not only leave a nasty smell but can also cause discolouration of metal parts. If the lathe is particularly dirty, then it should be washed down, and it is probably as well to stand it on a piece of newspaper for this. Paraffin or white spirit can be used for cleaning, but I have also found that some of the modern spray-on household cleaners of the non-abrasive type work well.

Swarf of all types is abrasive, but cast iron is worse than all the other metals. It is essential that metal dust and swarf be cleaned from slideways regularly, even though this may mean some stripping down of the machine. It is better to prevent the accumulation of such material in the first place and, if possible, thin strips of plywood or cardboard placed on the exposed parts of the bed should be used to prevent swarf settling on them when the lathe is in use.

Before putting the lathe away, a quick rub over with a thin oil will help to preserve it. Household furniture polish will protect painted surfaces. Modern specialist materials for preventing rusting, such as WD40, are excellent for protecting the machine.

When not in use, the machine should be covered. How this is done will largely depend on the facilities available to the owner. If the machine is picked up and stored in a cupboard, then, if possible, make a substantial wooden box to house it. This will not only help keep it clean, but will also protect it from damage if other items accidently get dropped on it or leant against it. If a box is made, then a little thought in its construction can result in a mini workshop being devised. This is very convenient as many of the accessories can be housed with the



A neat drawer on a Unimat 3 can house all the tools in safety in separate compartments.

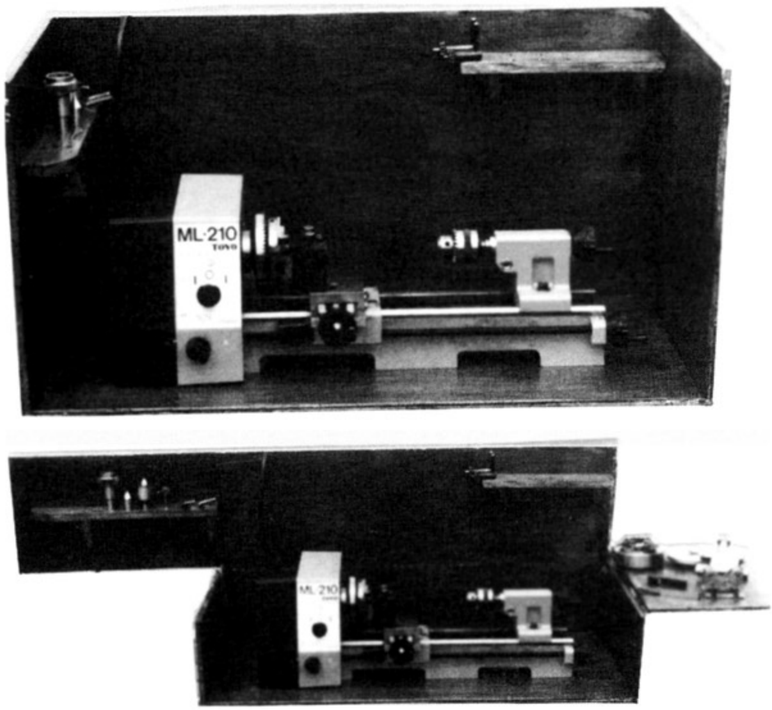
machine. Accessories are always something of a problem anyway and are difficult to keep in order. Boxes are one answer but, if they are of cardboard, they have a nasty habit of breaking up. Parts, also, get rather jumbled unless the box is properly organised. A tray with partitions is one answer to the problem. Another is a wooden block with holes in it, in which all the various parts are held in full view and easily available as required. These accessories are just as liable to damage by dampness as the machine, so care must be taken to prevent them getting damp in the same way as we do for the machine itself. Keeping small parts wrapped in newspaper assists in preventing them rusting.

If the lathe is kept permanently on a bench, in a shed or workshop, then aftercare becomes even more important to prevent deterioration of the machine. While such a building may seem perfectly dry, it is unlikely that it will be and, if you are not careful, the lathe will quickly rust if left unattended. Covering it with oil will help, and some sort of cover, such as an old blanket, will also assist. Dampness is usually the result of rapid temperature changes, so preventing these is important. For this reason, plastic sheeting as a cover is not advisable. Hot air striking the cold plastic rapidly causes condensation and dampness. If plastic sheeting must be used for some reason, it

should be laid on top of some absorbent material, and again an old blanket is ideal. If a blanket cannot be found, then an old coat will do the job just as well.

When in use, the lathe should be lubricated in accordance with the manufacturer's instruction. Many modern machines have pre-lubricated, sealed bearings, but the slideways and other moving parts also need to be lubricated. Very thin machine oil should be used. The types of oils used for car engines are far too thick for this purpose, more suitable is the sort used for sewing machines and pedal cycles.

Do not leave work in chucks for extended periods, as it causes a strain on the chuck. The same applies to drill chucks: drills should be removed before putting the lathe away. Although not quite so important, lathe tools should also be



A purpose-made box for a Toyo 210. The lid and front are held in place with hooks and eyes and are completely removable. In the box, apart from the lathe, can be housed the accessories. The lathe does not have to be removed to operate it, one side of the box swings outward, and the other down acting as a shelf for chucks etc. Such boxes can be designed to fit individual requirements and save wear and tear on the lathe as well as ensuring that everything is to hand as required.

removed providing their removal does not mean the removal of a tool that has been set correctly for a particular task.

Frequent checks on electrical fittings is advisable. Usually the compact lathe is used as a semi-portable tool and the result is frequent use of plugs etc. In particular, check that the wiring is still secure and that the screws holding it in the plug have not worked loose. Switches can cause some problems. They are in constant use and so are subject to a lot of wear. While all lathes appear to be fitted with substantial electrical equipment, it will still wear over a period of time and one must guard against such events. If switches start to feel slack in operation, or are sparking when used, they should be replaced either by the lathe owner, if he or she feels entirely competent so to do, or by a qualified electrician. The manufacturers will also fit new electrical parts, if required. Leads are also subject to wear and should be checked and replaced as required.

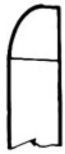
It is essential that care is taken to preserve both the life and accuracy of the machine.

3 LATHE TOOLS

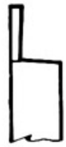
Most compact lathes have toolposts designed to accept small square-section lathe tools. The majority of manufacturers or suppliers can offer suitably shaped tools of the correct section to suit the lathe in question. It is important that tools be sharp when used, with finely-honed edges. This is particularly necessary with these small lathes, as, otherwise, there will be a tendency for the tool to tear the metal rather than cut it. The correct shape, with the angles ground to suit the material being machined, is also important. These angles are shown on the drawing on page 18. Grinding tools to these angles is not easy unless one has some form of reference. Small gauges should therefore be cut from sheet steel, and these used to match the various angles as the tool is ground.

It is best if a separate grinding machine is obtained with which to grind the tools. If this is not possible for one reason or another, a small grinding wheel can be used in the lathe. If this is done, it is essential that some form of guard is arranged to protect the operator should the grinding wheel break up during operations, as it occasionally does. The operator should also wear protective glasses while tool grinding is carried out.

If a grinding machine is used, then this will have a suitable rest on which to support the tool while it is being ground. If the operation is to be carried out in the lathe, then a rest must be used and I suggest that the hand turning rest, which will be dealt with later, serves the purpose well. The bed of the lathe must be covered with paper or cloth during grinding operations, and the machine must be thoroughly cleaned afterwards. A grindstone consists of abrasive particles held together with a compound. The size of the abrasive particles decides the coarseness of the wheel. As the wheel is used, these particles become detached from the parent material and, if not cleared from the lathe, will gradually grind down the bed and other working parts.

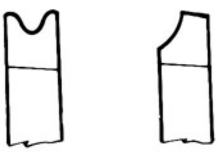


Round nosed roughing tool for taking the heaviest cuts of all



Parting off tool. These days it is more usual to use a blade in a special holder

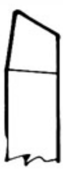
Screw-cutting tool (external). The point is ground to the thread angle



Typical form tools ground to specific shape of component

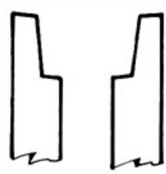
Round nose used for general purpose turning. Can be used for fine finishing as well as roughing. Also used to obtain radiussed corners

Roughing tool used for taking heavy cuts



Fine finishing tool used with very light cuts

Side facing tool. Ideal for facing across work



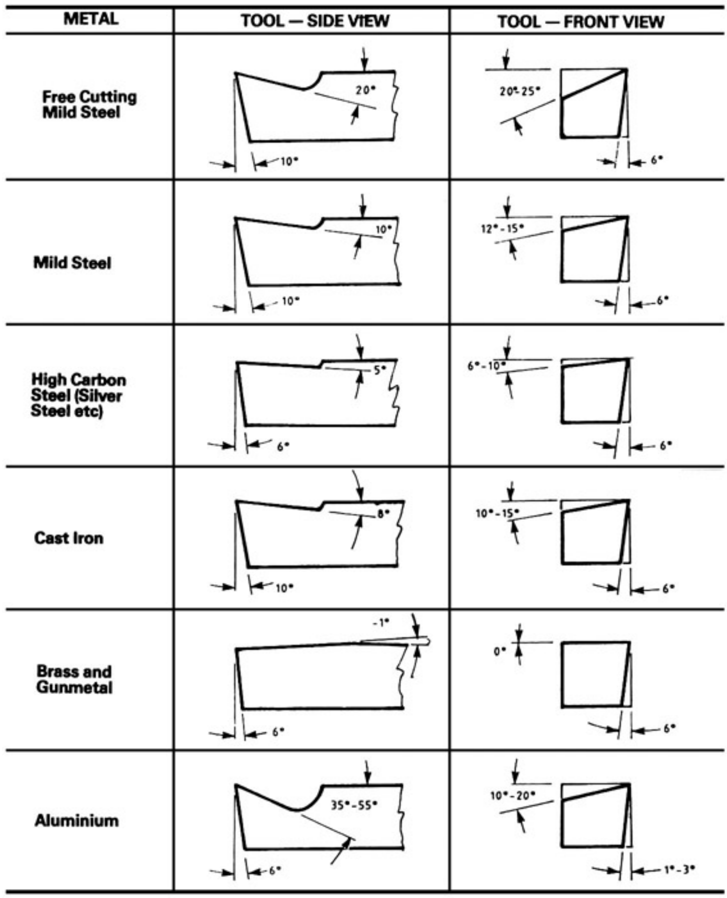
Right and left hand knife tools used for cutting shoulders—the term left and right refer to the the position of the shoulder being cut. The tool on the left will cut a right hand shoulder and is a right hand tool

Drawings of typical lathe tool shapes.

It is also essential that the tool is set to exactly centre height, and details of how to do this are set out in Chapter 5 together with some advice on how to make a height gauge.
So far I have described the sharpening and setting of a ready-made tool as supplied from a manufacturer. Sometimes the particular shape of a tool that is required may not be readily available and it will be necessary to make our own. This is not at all difficult, particularly as the tools required by these little lathes are themselves quite tiny. For most practical purposes, a tool can be made from a length of high-speed steel. Pieces of

A turning tool for a compact lathe made from carbon steel.

A tool with a separate screw-on tungsten carbide tip, shown here with a 20p piece for comparison.



Typical angles to which tools should be ground to get the best results.

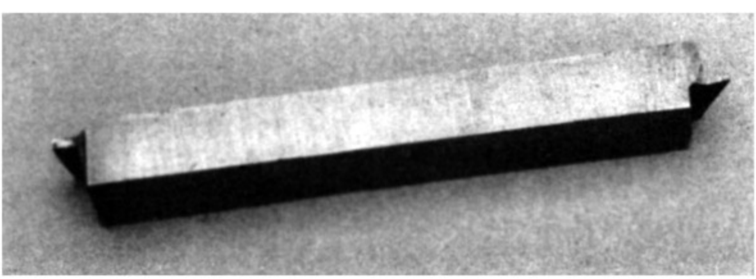
such steel are readily available at good tool suppliers or from model engineer stockists. If such steel is purchased, all that is needed is to grind it to the correct shape and then use it. Square-section high-speed steel should be used, for simplicity.

High-speed steel is also available in round form and this can be useful. To use round section material, it will be necessary to have a suitable tool holder, and again this will almost certainly have to be constructed by the operator. As with a height gauge, such a tool holder is very simple to make and is well worth the effort. It can be used for different shapes of tools and also for holding boring bars. It takes hardly any effort whatever to make a tool holder that is adjustable for height, and this can save much effort. The normal way of getting a tool to the correct

height is to put thin metal shims underneath until the correct height is obtained. It all sounds so simple, but what happens in reality is that the tool is packed with shims and the height checked and found to be correct. The tool is tightened down and found to have dropped during the tightening and is now too low. We put in another shim and find it has gone too high, and this process can be repeated for a long time until everything is exactly right. A stock of shims is kept for the purpose, of course, but, no matter how careful we are with them, they are constantly being sucked up the vacuum cleaner or mangled out of shape. The result is a constant game of 'hunt the shim'. With an adjustable height tool holder there is no need for shims at all.

If round tools are used, it is possible to make them from silver steel as well as high-speed steel. Silver steel is a high carbon steel which is capable of being hardened and tempered. As it is received soft, the tool shape can be filed in it, which is far easier than grinding. Chapter 16 describes how to harden and temper it. The use of silver steel is particularly recommended when it is necessary to make very small tools.

Nowadays, it is possible to purchase tools with carbide tips which are suitable for these little lathes. These come in two types: the tool with a tip brazed on permanently and the one with the replaceable tip. Small ones of the permanent tip type are rare in the size required for the compact lathe but the replaceable tipped types are quite easily available. These tools have several advantages over high-speed ones. The lathe can be revolved faster during operations for a start. They also stay cooler than the high-speed or silver steel ones, and so do not necessarily need a coolant. Some people say that a better finish can be obtained with them, but this will largely depend on the operator. A well-ground, properly-used high-speed tool will give just as good a finish if correct lathe speeds and feeds



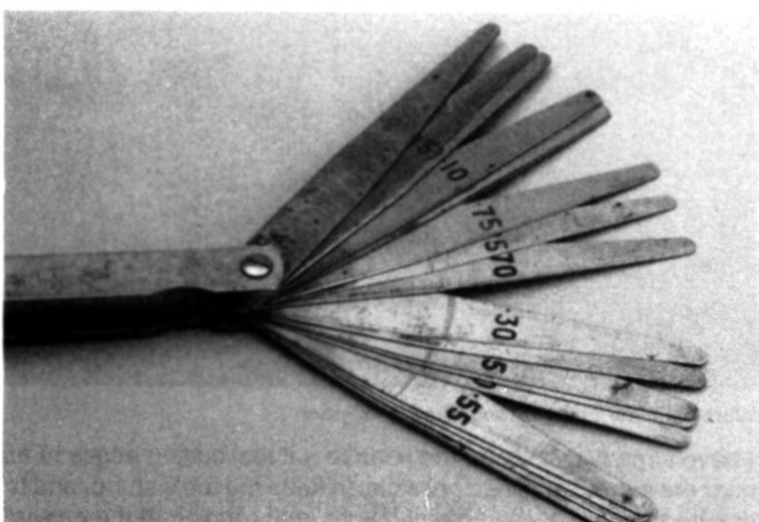
A small parting tool ground from high-speed steel.

are used. I agree, however, that to some extent the tipped tool will make up for sloppy operation. As they are not re-ground, and the tips last longer than the cutting edges of a high speed tool, they have some advantages. With the longer-lasting cutting edges the work does not become ragged so quickly and, even if the tip becomes worn, it is simply a case of unscrewing the worn one and screwing in a new tip. This means that the cutting edge will be virtually in the same place as it was on the old one, whereas taking a tool out and re-grinding it means that it will be fitted in an entirely different position, making it difficult to re-start operations in the correct position.

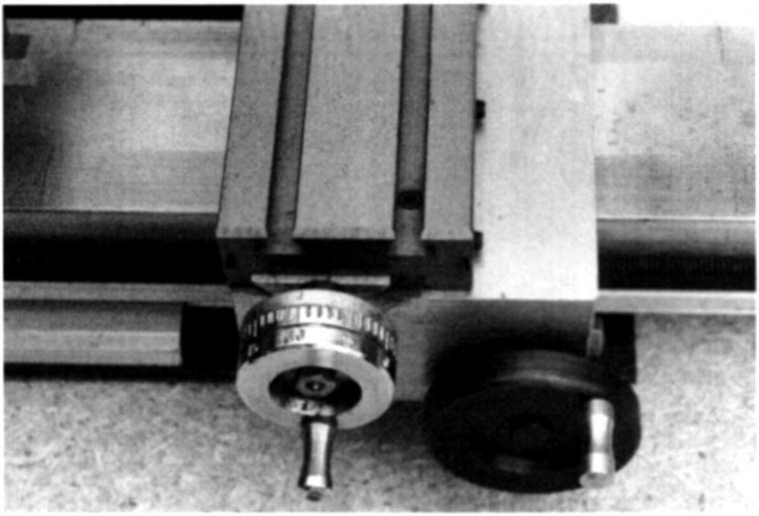
4 TURNING OPERATIONS

In any book on the lathe, there are numerous operations to be dealt with and equipment to be described. In the midst of all this, it's too easy to forget what the beginner at least needs to know, and that is the basic turning operation. There are three types of general machining for which we use the lathe: internal turning or boring is dealt with elsewhere, but here I propose to deal with facing and ordinary basic turning. Like everything in this book, there is a certain amount of overlapping in the descriptions. This is inevitable and cannot be helped, as what applies to one operation may well also apply to another.

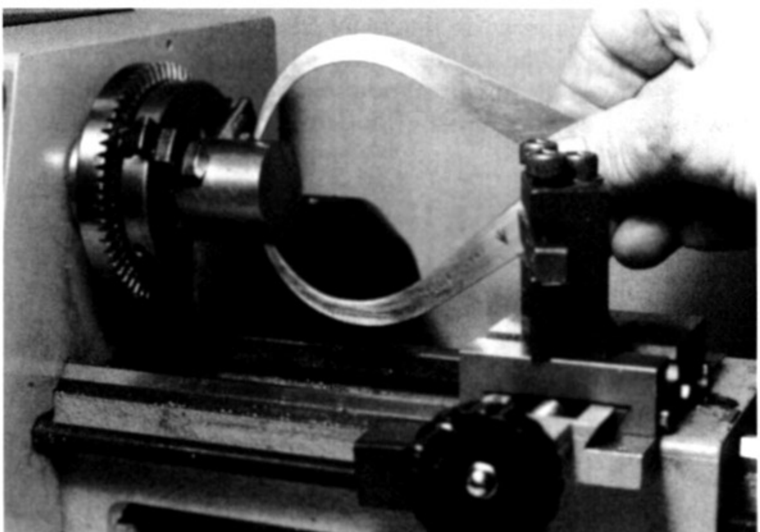
Basic turning can be described as running a tool along a piece of revolving metal to reduce its diameter, but knowing how to do so and get a really good result is the important thing.



The tool should make contact with an ordinary feeler gauge as used for work on motor cars.

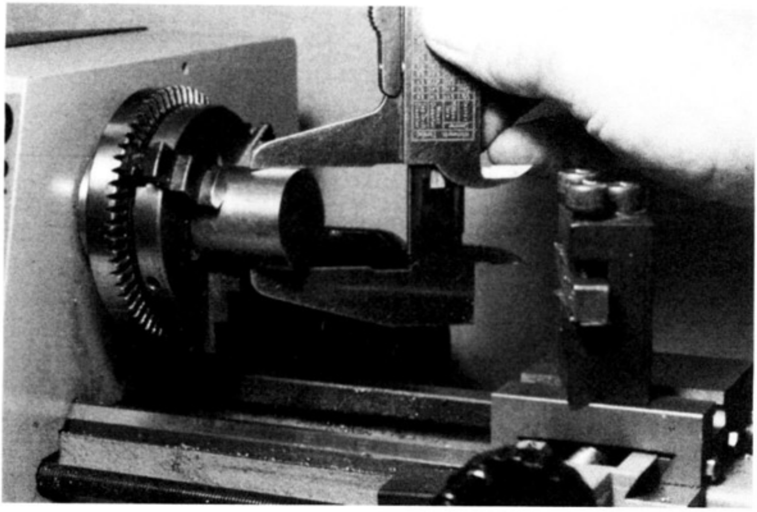


Dial graduations on a cross slide which are used to position the tool to the work



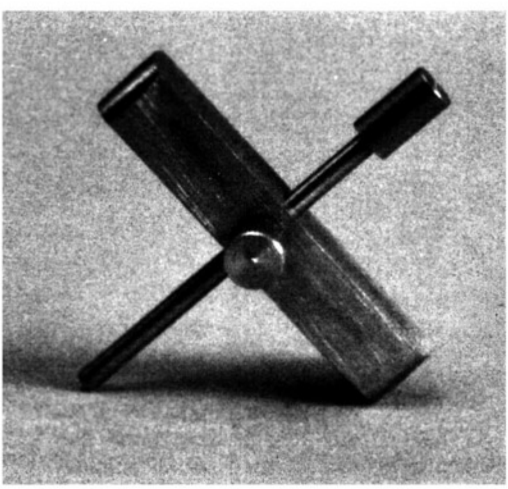
Work diameter being measured with calipers

I have already discussed the need to get tool cutting edges to as near the correct angle as possible, to keep the tools sharp, and to ensure they are at the correct height, and running at the correct speed. However, it cannot be stressed enough that these things are the basics of good workmanship.

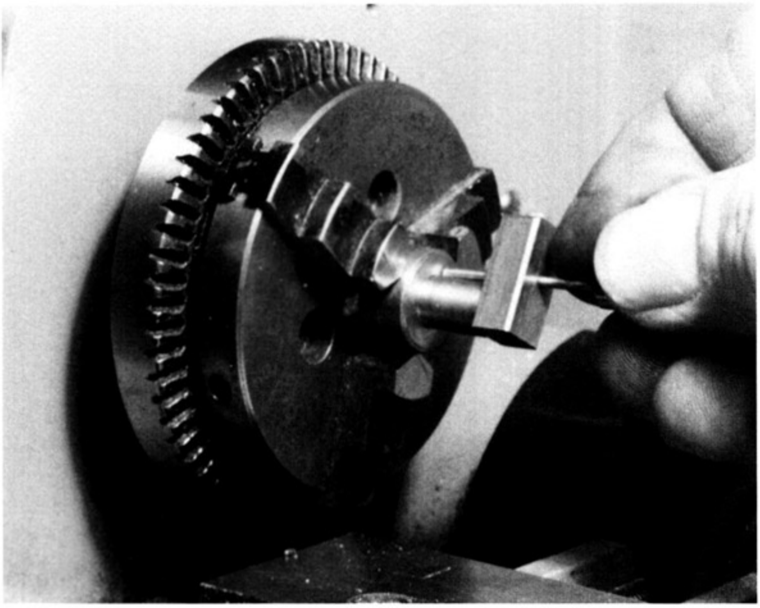


Work diameter measured with a vernier gauge.

Having sorted those basics out as well as we can, we turn to the actual cutting of metal. Let us assume that we have apiece of bar material of a diameter of ½ inch or 12mm, to be reduced for half its length to ¼ inch diameter or 6mm. I must also assume that it is held perfectly concentrically in the lathe, as it should be. The material should be clearly marked to the length of the reduced section. This can be done with a scriber; how it is measured will depend on the operator and what measuring equipment is available. The mark should be made in such a way that it is clearly visible when the lathe is rotating at the turning speed. I like to rotate the



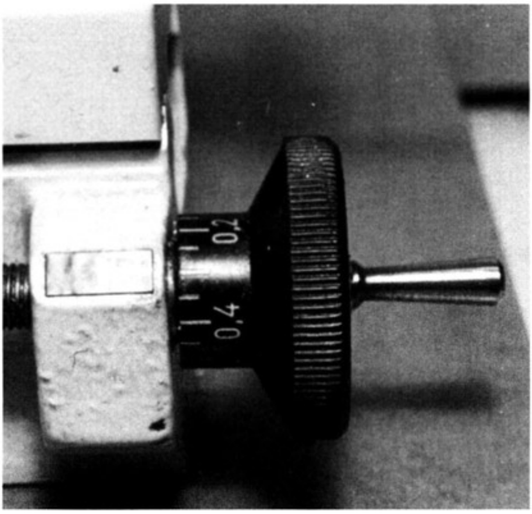
A depth gauge as used to check the length of the work that has been turned. This is a simple home-made tool.



Using a depth gauge to check the work.

lathe by hand with a vee-pointed tool in contact with the metal to score it right round. I also bring the mark just short of where I ultimately want it to be. For example, if I want to reduce a length of one inch or 25mm, I will make the mark 31/32 inch or 24mm from the end where turning will commence.

With the lathe switched off, I then bring the tool to the metal



The dial at the end of the lead screw can be used to ensure that each cut travels the same length.

but put a feeler gauge of known thickness between the tool and the work. Do not squeeze the tool in hard – it must just touch the gauge. Check the measurement on the cross slide handwheel and remove the gauge. You now know that the cross slide will move in to the reading plus the gauge thickness just to touch the work. Start up the lathe and move in the cross slide a little more than the required reading, say about ten one thousandths of an inch or half a millimetre.

Commence turning for a short distance, then wind the tool back towards the tailstock and stop the lathe. Measure the work diameter. In theory it should read under the original diameter by the extra amount of cross slide movement. It most probably will be less than that because of the squeezing action on the feeler gauge. However, the exact position of the cross slide in relation to the diameter is now known, and operations can commence from there.

The tool can now be traversed to the mark which was made earlier. Several cuts can be made until the cross slide reading begins to show that the work is nearing the finished diameter. At this point, the length of the turned section can be increased to full size, and I use a depth gauge to check this. Final turning can be done checking each cut for size with a micrometer until the work is correct.

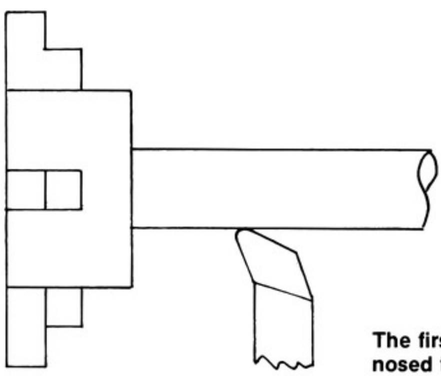
So far so good, but there are certain things we need to remember for a good finish. Firstly, not too much tool overhang, or shake on the tool will give a bad finish. The saddle should be operated under power if it is possible. It is not possible to control it by hand as smoothly as it can be done mechanically. If only hand operation is available, then use two hands on the wheel and, as it rotates, pass it from hand to hand in an effort to keep it moving slowly and regularly. Take only light cuts for finishing; heavier ones can be taken for roughing down. Before the final cut, rub a slip stone over the top of the cutting tool to hone up the edge. Use a cutting lubricant if appropriate.

Where work is to have a number of different diameters turned on it, always turn the larger ones first. Work should always be held by the largest possible diameter. Holding a large piece of metal by a small diameter section is asking for trouble. At the very least, a bad finish will result and it may even cause the work to slip in the chuck.

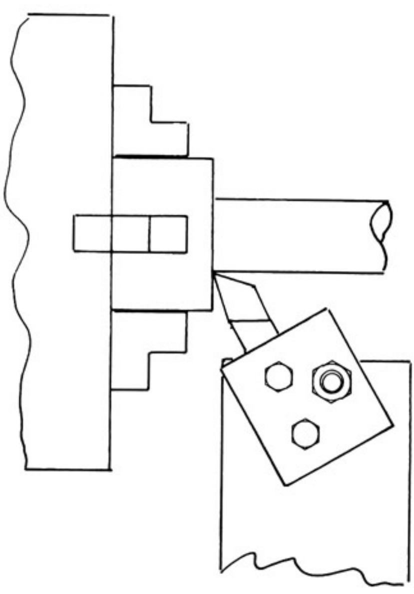
Facing or turning across the diameter of work is carried out in a similar manner to ordinary turning. Here, the fact that the tool is not at centre height will soon become obvious, as either

a large pip will be left or there will be a bulge as the tool rides up over the centre of the work. Power feed on a cross slide is most unusual and so hand operation will be necessary. As in the case of ordinary turning, the movement across the work should be smooth.

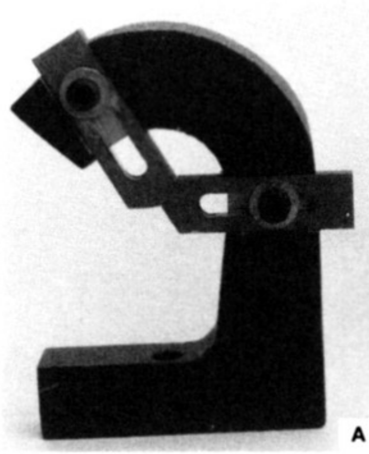
Parting off involves the use of a narrow tool to cut through metal, and the secret of any parting off is rigidity. If the tool, tool post or cross slide is not absolutely rigid, the parting tool will tend to dig in under the work and will snap off. It is absolutely essential to wind the tool in very slowly and under no circumstance must it be allowed to stop during operations.



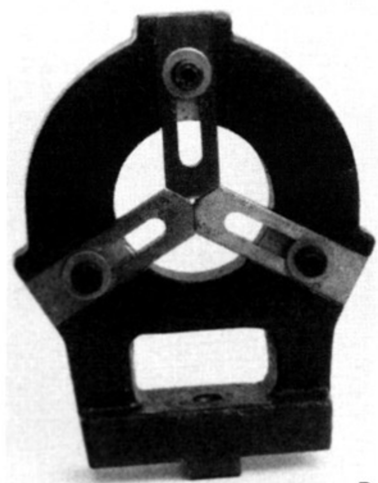
The first cuts made with a round-nosed tool to remove metal quickly.



A knife-edged tool used to turn right up to a shoulder.



A



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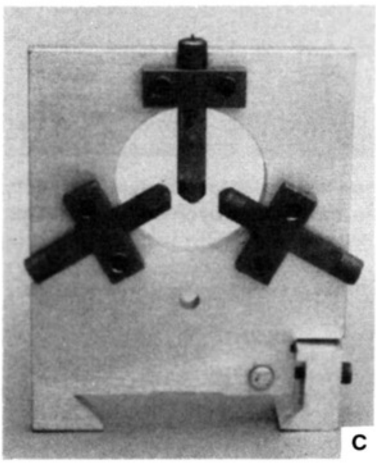
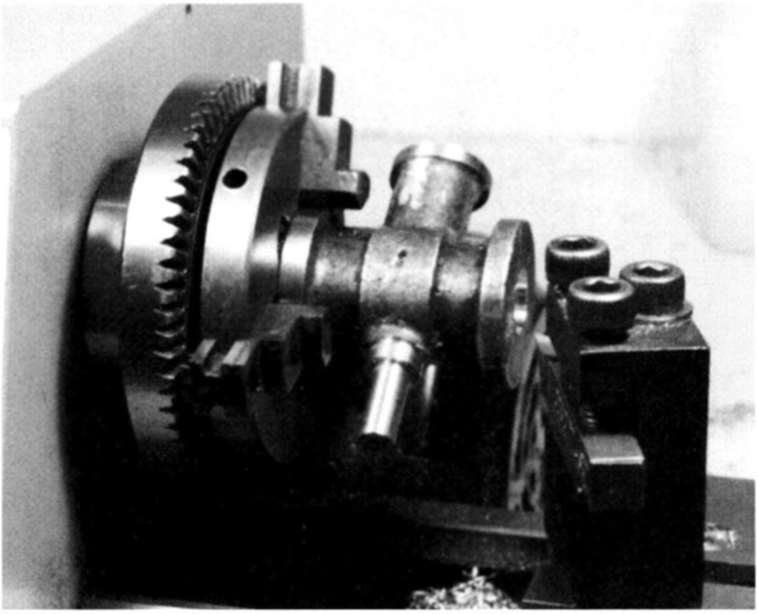


C

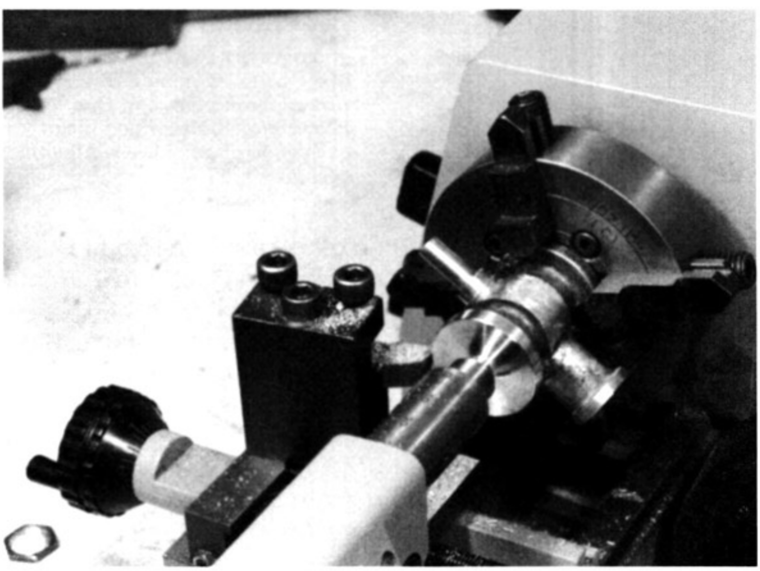
Work should, where possible, be supported by a steady. The photographs show three types: A, a Cowell two point, B, a Cowell three point and C, a Peatol three point which it can be seen is of an entirely different design.

The biggest problem with parting off is caused by a build-up of heat caused through the fact that as the tool goes into the metal the heat is retained in a confined space. This can cause expansion of the work that will trap the tool blade. Slow feeding, and plenty of coolant is the only answer to the problem, but do also check thoroughly that no vibration is present when the work is carried out.

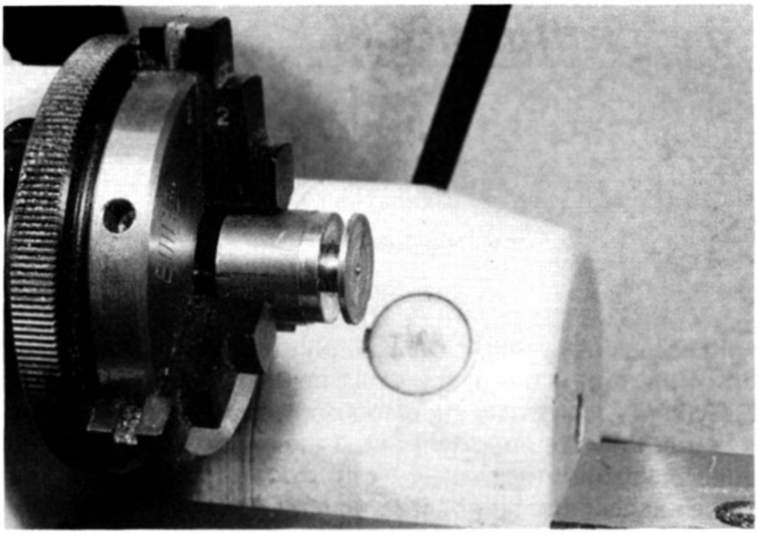
Eccentric turning, or turning off-centre, follows the same pattern as ordinary work and the only thing to remember is that, during early cuts, the tool will be in intermittent contact with the work. This means that there is a heavy shock force each time the tool contacts the metal. Again, taking it easy is the only answer. Similar problems arise when turning square or



An unusual shaped casting held in a three-jaw chuck for facing off. The hole in the casting which was called for in the drawing has been drilled first. This allows the facing tool to run into it.



A similar casting has been faced and is then supported with a centre whilst the outside rim is turned.



A piece of bar being parted off to make a spacing piece.

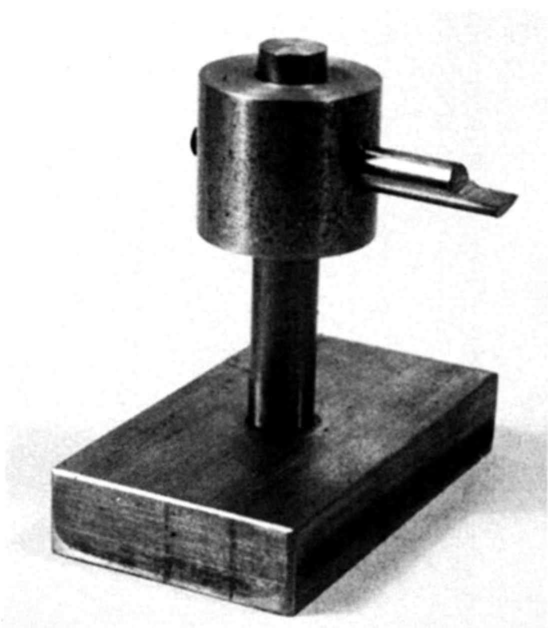
rectangular metal to the round. Apart from the initial setting up which will vary with each individual job.

When turning castings, if possible the outer skin must be removed in one cut. This is not always possible and, where it cannot be done, it is again a case of taking it easy and preventing heavy shocks on the tool. In all turning operations it is essential that the work is absolutely secure before operations commence.

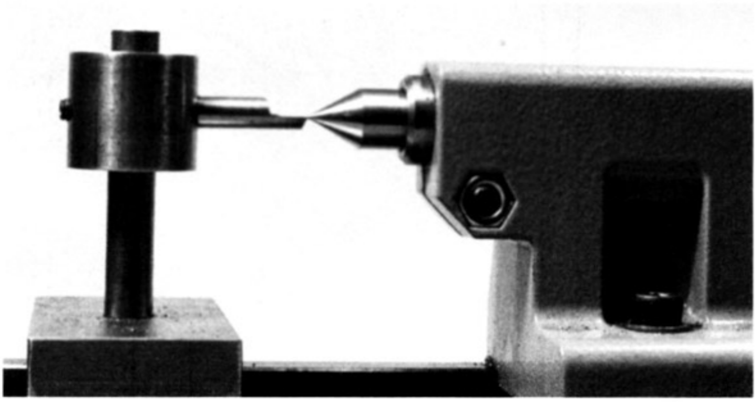
5 CENTRE HEIGHT

For successful turning, it is absolutely essential that the cutting tip of the tool is set at the exact centre height of the lathe. Elsewhere you will read about tool angles and their importance. It is true they are important but, if the angle of the tool is not quite exact, then no great harm will be done. If the tool is not set at the exact centre height, then no matter how correct the tool angles, cutting of metal will not be as successful as one would want it to be.

It is therefore essential that the owner of a compact lathe makes his first task to learn to get the tool height right. One fairly obvious way of setting the tool is to line it up by eye with a centre in the headstock. To do this, make sure that the eye is

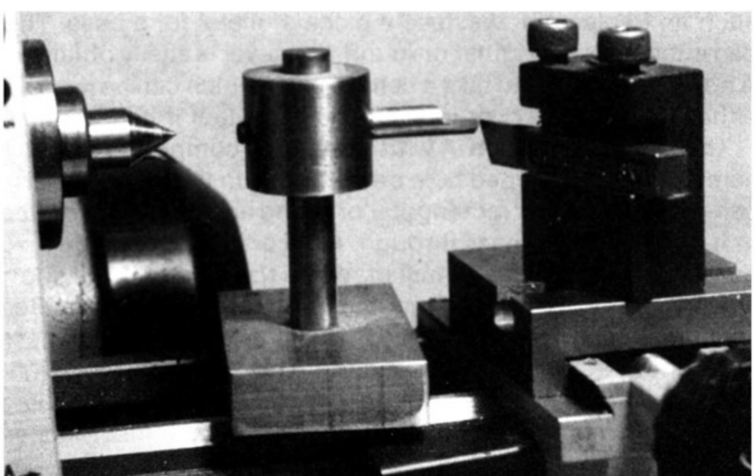


A home-made centre height gauge.

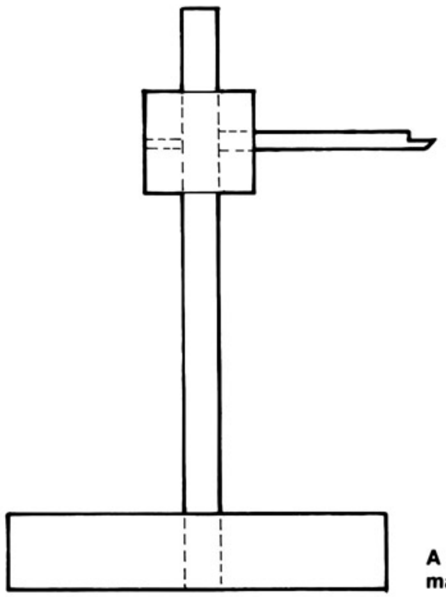


Checking the height gauge against the tailstock centre.

level with the tip of the centre, otherwise the angle of view will cause the apparent matching of tool and centre to be distorted. There is one other difficulty with this method and that is that the lathe centre usually has a slightly rounded end, and this too can make it difficult to see when it is lined up exactly with the tool. Sometimes, too, it is necessary to set a tool in position while the work is held on the lathe. A typical example of this is where a round-nosed tool has been used for roughing work and one with a finer tip is needed for finishing. If the work is taken off the lathe it will not be possible to set it back accurately, and so the only answer is to line up the tool with a tailstock centre. There is nothing wrong with such a method but twisting the tool round



Checking the tool height.



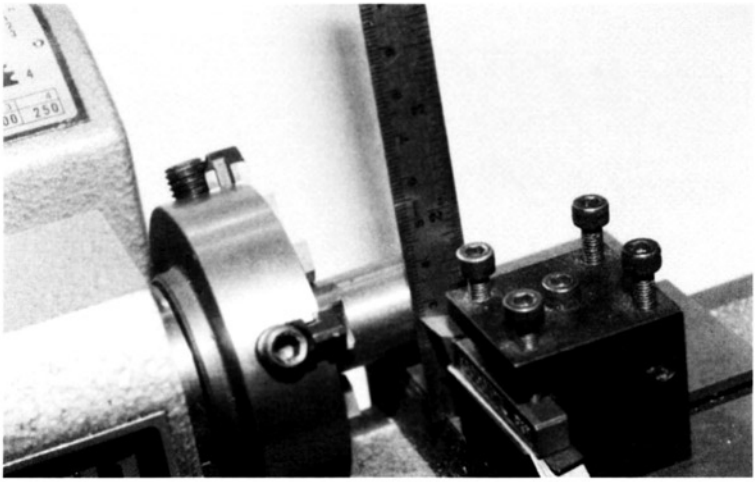
A drawing to enable you to make your own height gauge.

to touch a centre in the tailstock can sometimes be difficult. We need to find other methods of achieving the object.

I believe that the first thing that anyone should do on acquiring a lathe is to make a centre height gauge. This will only take half an hour or so and, if a scrap box is to hand, the centre finder can probably be made of bits found in it. To make such an implement, we need a piece of metal for a base. This can either be rectangular or round, whatever is easily obtained. A hole is drilled in it to take a central pillar which can be made of either steel or brass, or indeed stainless steel if it is to hand.

The pillar can be held in with a retaining compound or with a screw through a tapped hole cross-drilled in the base. The arm can, again, be either rectangular or round and has a hole drilled in it for the pillar to pass through. A flat on the end can be filed but it is better if it can be milled. While the filed end will show when the tool is lined up with the end, in the case of a milled section it can be guaranteed to be the same thickness throughout the whole milled section. This will allow the height of the tool to be checked, not only by eye but also by standing the end of a short ruler on it and checking that it just touches the tool tip.

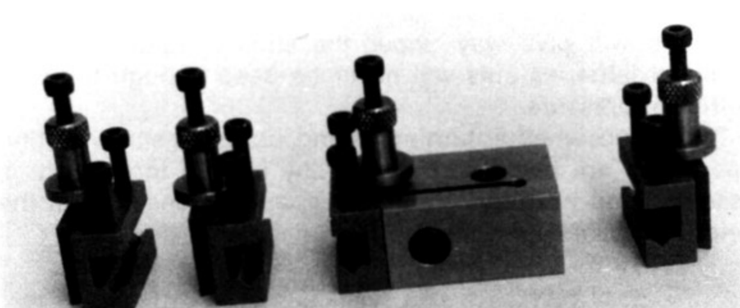
You can make a centre height gauge to any design you wish and, in particular, to suit your needs. Once the arm has been



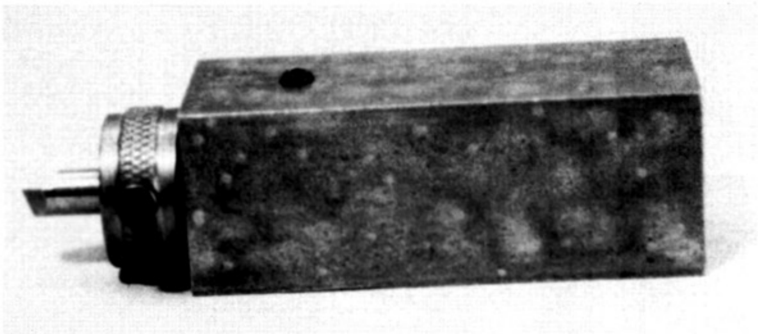
Checking centre height with a 6in ruler. If the top of the ruler leans away from the operator the tool is too high, if it leans towards the operator, the tool is too low.

correctly set at centre height, it should be locked in position so that it will not move. However, even though it is locked, it is as well to check it from time to time. For those planning extensive use of their lathe, the end of the arm can, with advantage, be hardened if a suitable material for hardening has been used.

There is another way of finding centre height with a high degree of accuracy and without the need to set up the gauge. The method can only be used on thick material. All you do is to put a short ruler between the work and the tool and just lightly tighten the tool on to it. If the tool is below centre height, the top



A tool post with adjustable height inserts by Cowells. The advantage of this is that the tools can be taken off and re-set without the need to check their height.

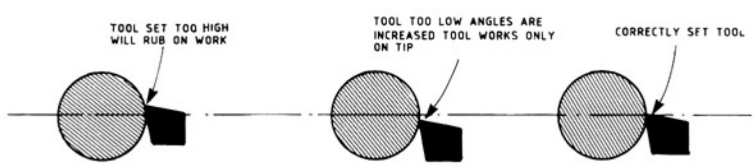


A simple home-made adjustable height tool holder. An eccentrically drilled barrel rotates in the holder and as it is rotated so the height of the tool will vary.

of the ruler will lean towards you. If it is above, it will lean away. It is fairly obvious why the method will only work with thick bar, as thin bar is liable to bend away from the tool when it makes contact. Nevertheless, it is a quick and easy method of checking the tool height in relation to the work.

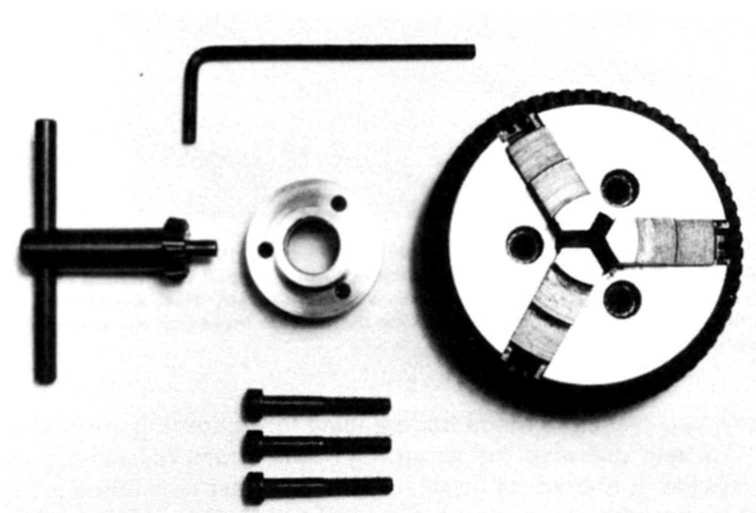
In order to get the tool at the required height, it will have to be packed up with shims on most tool posts. A tool post that is height-adjustable has an advantage, as there is no need to pack the tool. When packing with shims, it will usually be necessary to pack the tool until it is just a fraction above centre height as, when it is clamped up, it will inevitably sink. Normally metal shims are used - in particular thin aluminium as this will compress under pressure and so give some adjustment - but there is no reason why the packing immediately underneath the tool should not be of thin card, such as a postcard. This will also compress and allow some adjustment. It is unlikely that the card will give way under the strains imposed with a compact lathe, as cuts will never be deep enough to apply sufficient pressure.

To sum up: whether turning, facing, boring or screw cutting operations are being carried out, the correct tool height is essential and no effort should be spared to ensure that the height is absolutely right.

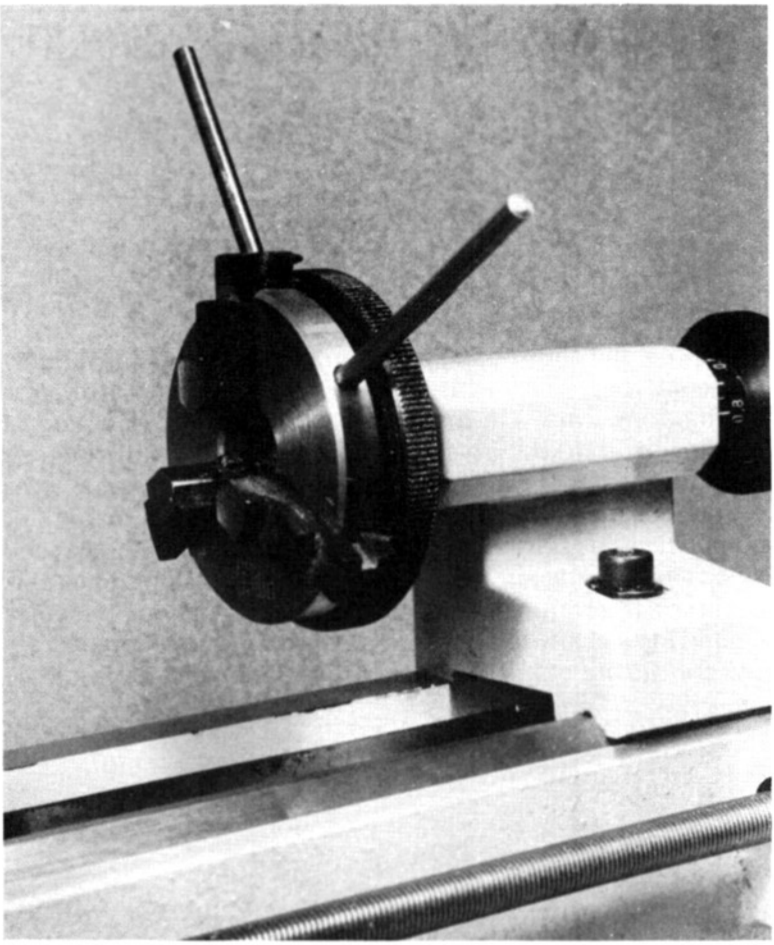


6 USING THE THREE-JAW CHUCK

The three-jaw chuck used with the compact lathe is invariably self-centering. This means that, when the chuck key is rotated, all three jaws move in or out depending on the direction of rotation of the key. This type of chuck will hold round or hexagonal work but will not directly hold square material or, as a rule, castings. While most three-jaw chucks made for compact lathes start as very accurate pieces of equipment and with care will remain in good condition for a long time, this accuracy is soon lost if misused and so the chuck becomes limited in its ability to cope with precision turning. Some three-jaw chucks are of the lever scroll type, and instead of a chuck



A three-jaw chuck of the type used on the Toyo 210 lathe. The chuck fits to the lathe with three screws passed through the holes that can clearly be seen. Included in the picture is an adaptor ring, to which the chuck is fastened with the screws. The ring can then be screwed complete with chuck to the Cowell lathe.



This photograph shows another type of three-jaw chuck, for the Unimat 3. Although working on the same principle as the Toyo, it is operated with two bars acting as levers rather than with a chuck key. Here we see the chuck mounted on the tailstock using the outside thread on the tailstock barrel.

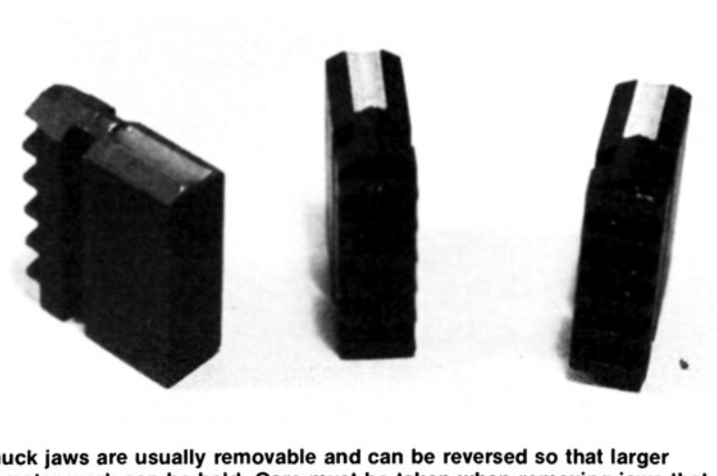
key, two pieces of metal bar are used for tightening purposes.

To help preserve the accuracy of the chuck for as long as possible, it should be maintained in the best possible way. It must be kept clean, and the seating where it fits to the lathe must be free of swarf when the chuck is being fitted. Unless it is absolutely impossible to do otherwise, the work should be pushed right into the chuck before tightening up. Gripping work by the outer edge of the jaws leads to a strain on them that

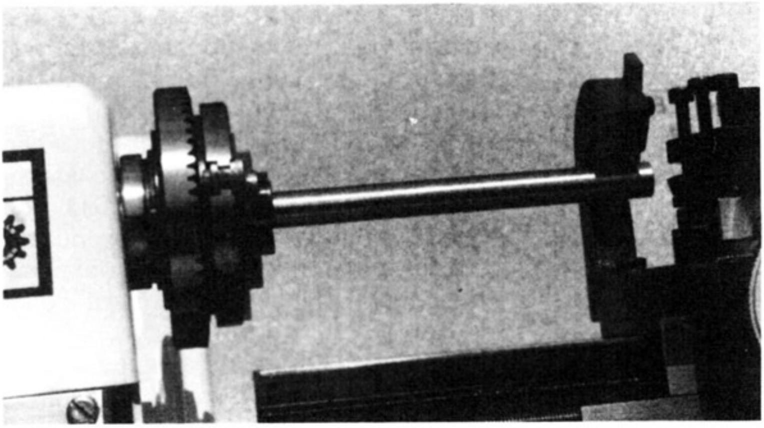
results in wear at the ends, known as 'bell mouthing'. The longer this situation can be avoided, the better. It is, of course, sometimes impossible to avoid gripping work in this way. In such circumstances, it is easy to over-tighten the chuck and strain it. It is not possible to tell you how far to go when tightening up, as this is a matter for the individual, and largely common sense. However, if the strain being imposed is borne in mind, it will help prevent over-tightening. If it is essential to turn a number of components that would need to be gripped by the outer edges of the chuck, then some form of collet attachment should be made to hold the work.

Before putting work in the chuck, it must be wiped over to remove grease, dirt and swarf that might be on it. These things cause the work to be lacking in accuracy. Once the work has been set and tightened, it should remain in the chuck until all operations are completed, as it will not be possible to remove it and replace it accurately. However, having said that, it is bad practice to leave work in the chuck for extended periods as this causes strain. Every effort must then be made to complete operations as soon as possible so that, when the lathe is not in use, the chuck will remain empty.

From time to time, the three-jaw self-centering chuck should be checked for accuracy. This is done by inserting a bar of metal and checking with a dial gauge or similar indicating device to see whether it runs accurately. The diameter of the bar should be as large as possible, and it is as well if silver steel

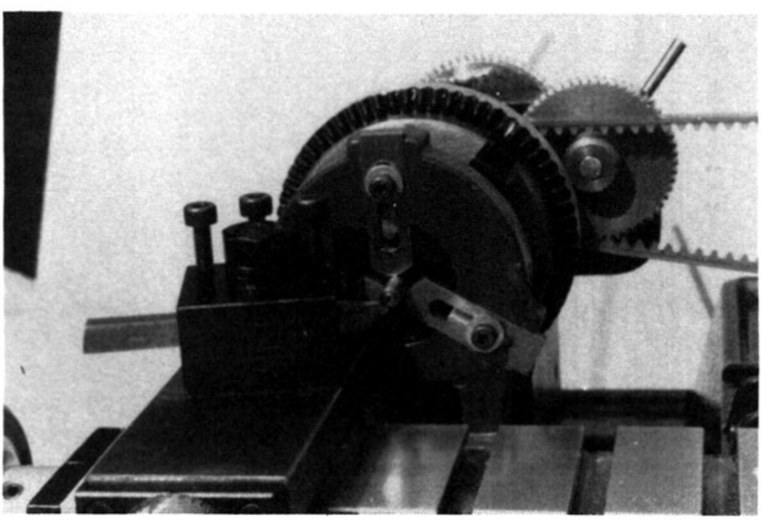


Chuck jaws are usually removable and can be reversed so that larger diameter work can be held. Care must be taken when removing jaws that they are returned in exactly the same sequence as they were removed, otherwise the chuck will not be accurate.



Where possible work held in a three-jaw chuck should be supported like this with a steady.

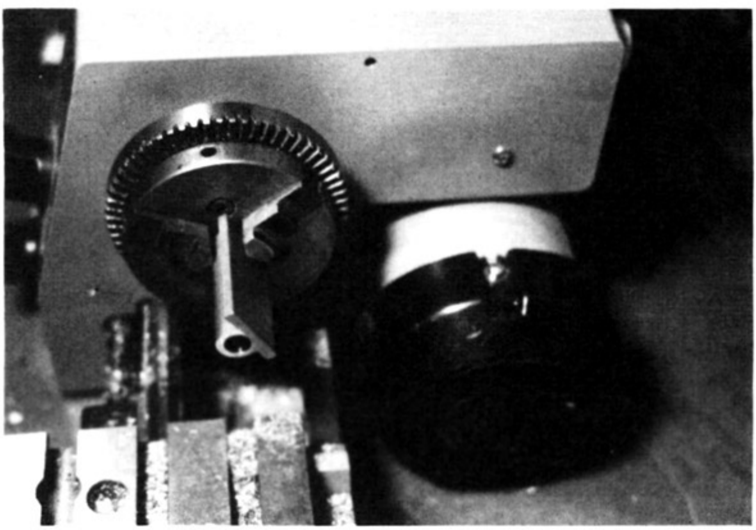
is used for the purpose. Ordinary mild steel bar frequently lacks in accuracy, while silver steel is manufactured to a very high standard of tolerance. If the chuck is found to lack accurancy, then a note should be made of the jaw number where this innaccuracy shows up. A piece of metal shim, which is a very thin piece of metal, can be used to regain the accuracy and the shim can be kept to be used at all times for the purpose.



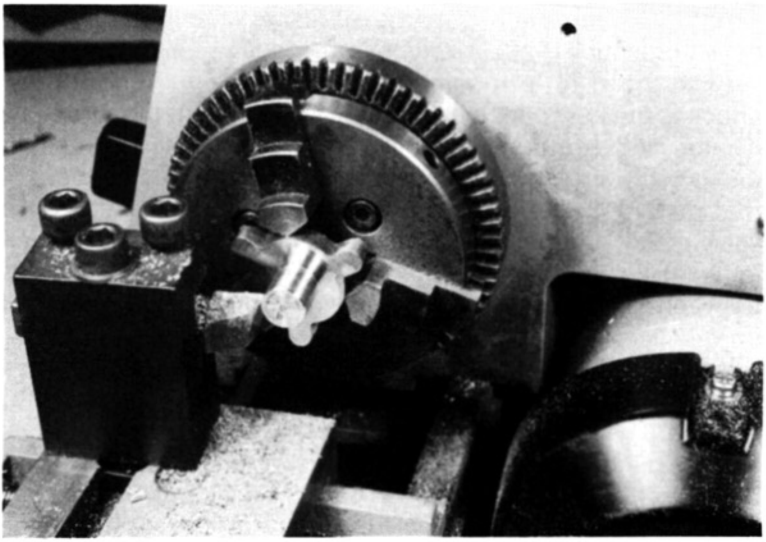
Work held in a three-jaw chuck and being machined on the edge where the steady supports it.

Although the main purpose of using the three-jaw self-centering chuck is accurately to turn concentrically, sometimes we may need to turn something eccentrically. The four-jaw chuck is the best one to use for this purpose, but the three-jaw can be used by putting a piece of metal of suitable thickness in one jaw and so throwing the work off-centre by the thickness of that metal insert. For example, if we are making locomotive valve gears, and this calls for two eccentrics with a $\frac{3}{32}$nd inch or 2mm throw, then a piece of strip metal of that thickness between one jaw and the work will make sure that the throw is correct.

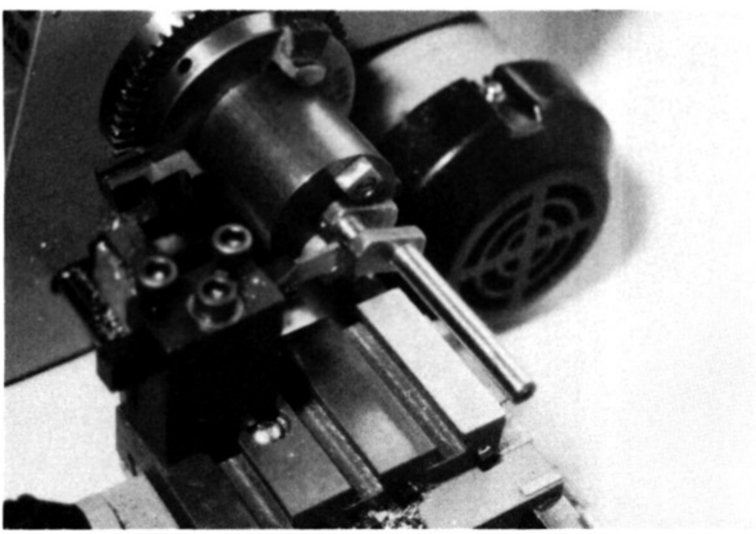
Where a number of components are needed from square material, it is possible to use the three-jaw chuck if an adaptor is made. The reason we might wish to do this is because, while the use of the four-jaw chuck for such work is in many ways better, setting it up is very time-consuming work. The use of a split collet in the three-jaw will make it possible to change the material quickly, with no loss of accuracy. If doing this sounds complicated, there is nothing to worry about. The collet needed means only a piece of thin walled steel tubing to fit the corners of the square bar. A saw cut is made lengthways through the tube and the metal put in this and in the chuck. As the chuck is tightened up, so the tube will tighten on the square



Although basically a three-jaw self-centering chuck will only hold round or hexagon bar it is at times possible to hold odd shaped work truly in it. This is a brass extrusion used for a bearing which was found to run quite accurately in the chuck.



Another example of irregularly shaped work held in a three-jaw chuck. This casting is in fact round but has three cast in lugs. It was possible to fit the chuck jaws between these.



In this photograph a crank shaft is being machined. The main shaft presented no great problem but the crank was a different matter. A bar of metal was drilled off-centre and mounted in the three-jaw chuck. The crank shaft was secured in it in such a way that the crank ran true. Machining was then straightforward.

bar; the amount of tightening is, of course, limited to the width of the saw cut.

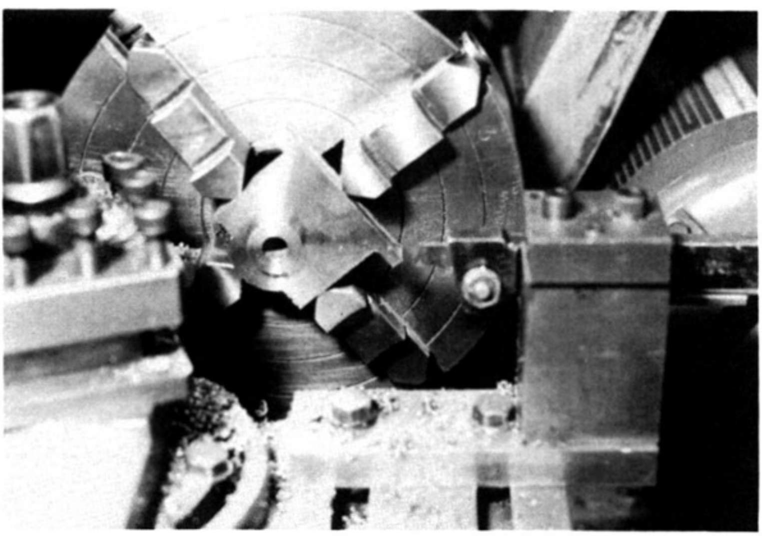
Where possible, set work in the chuck so that it will locate with the main body when it is in the jaws and, in so doing, there is a register to ensure that the work is absolutely square. If possible avoid putting thin work in the chuck, however when it is essential to do so this raises a further problem in addition to that of the strain being caused on the jaws. This is the fact that the work may actually lie at an angle without this being obvious to the eye. In this case a block should be slipped behind the work while it is tightened up and the work pressed against this to make sure it is square. The block must, of course, be removed before operations are commenced.

When work has been set in the chuck, make sure that the key is removed. Although the small chuck keys used with compact lathes are not anywhere near as lethal as the larger types used with bigger lathes, starting the lathe up with the chuck key in is still an act which, to say the least, will get the adrenalin going. One has to be quite smart to avoid the key as it flies from the chuck, and then spend a great deal of precious time hunting for it, not to mention the possibility of replacing the nearby window.

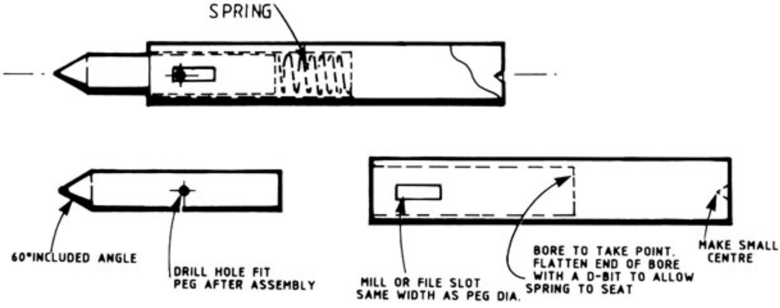
7 THE FOUR-JAW CHUCK

If I had to choose between a lathe with a three-jaw self-centering chuck and one with a four-jaw independent one, then the four-jaw would win hands down. Fortunately, most of us are able to have both, and so get the best of both worlds. The four-jaw chuck is a very versatile accessory and no model engineer should be without one. Apart from particularly awkwardly-shaped castings, or work that is so large it will not fit between the jaws even when they are reversed, there is virtually nothing we cannot hold in the four-jaw chuck.

All the jaws are, of course, controlled independently of each other and this fact allows odd shapes to be set in the chuck. The jaws are reversable and this allows the holding of larger work, but it has another advantage. There is no reason why all the



A bearing set in a four-jaw chuck for machining, showing how the chuck can cope with odd shaped work by moving one or two jaws further from the centre than the others.

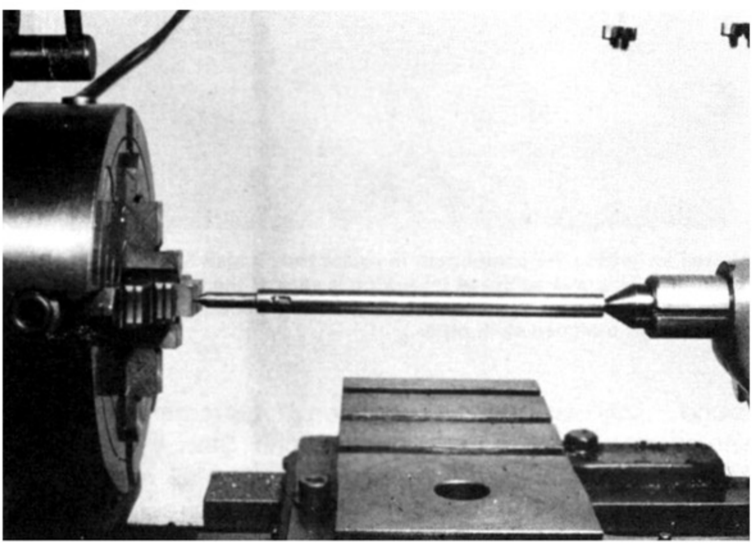


Drawing showing how to make a centre finder.

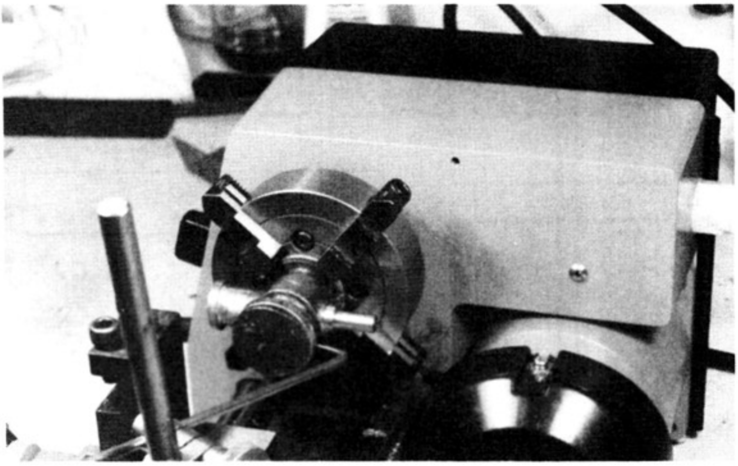
jaws should be used in the same way. We can, for example, if there is a very lopsided piece of material to be machined, put two jaws in the normal position and reverse the other two. Equally, we can use three and one in whatever way we choose.

When work is held in the chuck, then obviously it is held there for some form of machining to be carried out. It may be turning, drilling, or boring. Whatever it is the work will need to be set in such a way that the machining will give the finished result required. For this we need a guide of some sort, so let us have a look at some examples.

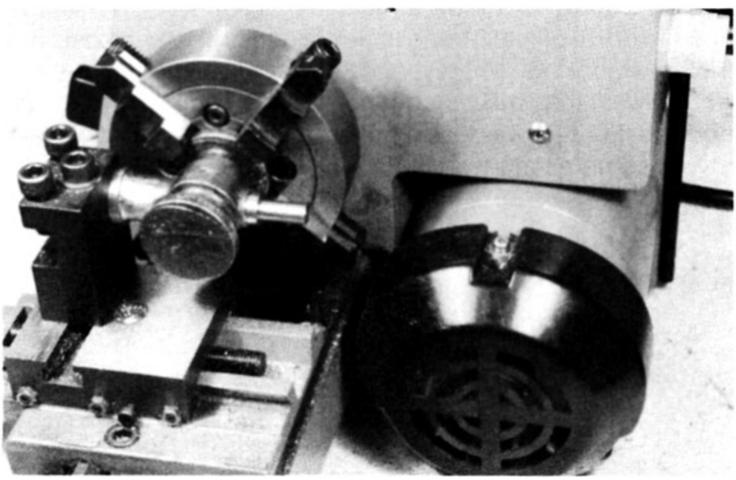
First of all, suppose we want to turn a section of square bar



The centre finder in use.



Sometimes it is not possible to set work with a centre finder. Here we see a casting being set up with a scribing block.



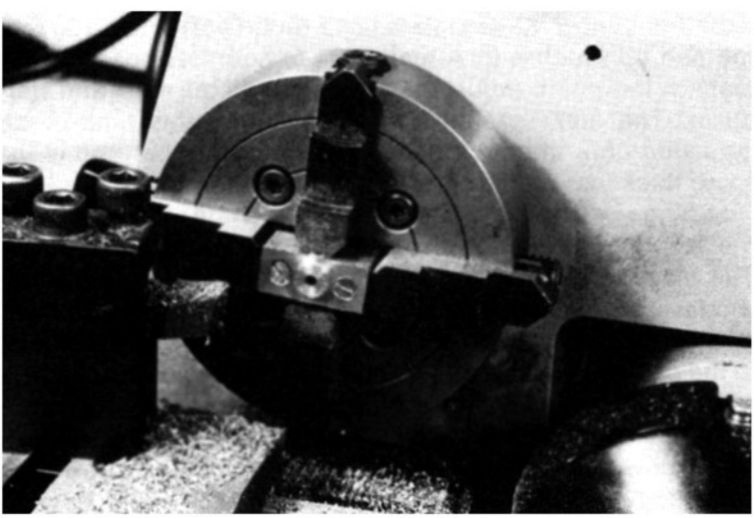
As well as getting the component to rotate truly it also had to sit square in the chuck. This was achieved by setting it against the lathe tool post. Several attempts had to be made before both the scribing block and tool post settings matched each other.

round. This is quite a common requirement in model engineering and has many applications. Start by setting the work in the chuck and, by eye, getting it as near true as possible. This can be done by referring to the circular marks on the chuck face in relation to the steps on the jaws. Set up a scriber so that it is held rigidly, but with enough of the scriber

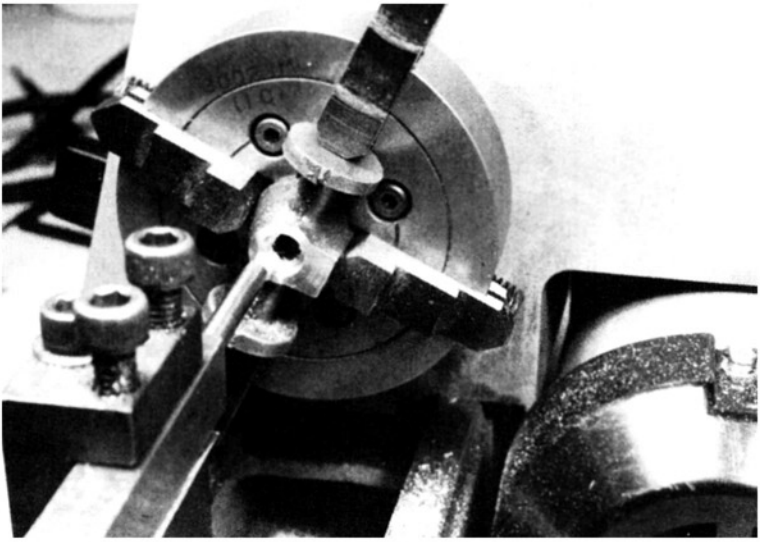
standing out to be flexible. Rotate the work by hand and set the scriber just to touch a corner of the square bar. As the work is rotated it can be seen which jaw needs adjusting to get the work true.

Of course, the fact that one edge is contacting the scriber while the other is a considerable distance away from it, does not tell us which of the edges is in the correct position. Look again at the marks in relation to the jaws and this will indicate where adjustments have to be made. These are made by loosening one jaw and tightening the opposite one. Keep rotating the work and making adjustments until the scriber just touches each corner. It is then possible to let the actual lathe tool take the place of the scriber. Rotate it once and any discrepancy can clearly be seen as the tool will score the side that is out of true. If extreme accuracy is required, a clock gauge or similar indicator can be set to touch the corners of the metal and a reading taken from that. When you are certain that the work is right, tighten each jaw. Start at one, and go round in sequence two, three and four. Twist the key by exactly the same amount each time or the work will again go out of true. It should be checked again after this. Tiny discrepancies can accidentally be made by just tightening a jaw without loosening the opposite one.

Rectangular bar can be dealt with in the same way as square



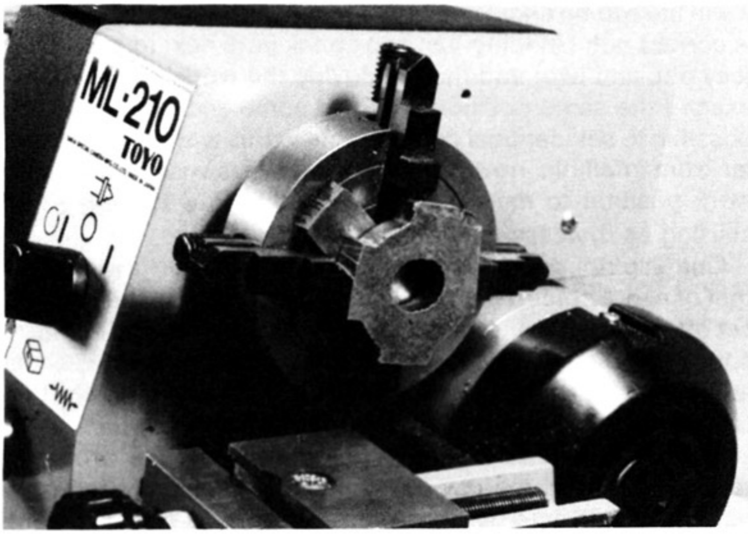
Turning a boss on a piece of work using a four-jaw chuck. Two pieces of metal have been screwed together and this gave extra metal to hold in the chuck and so allowed extra support.



Another example of a four-jaw chuck coping with an odd shaped casting which is being bored.

material. In the case of round material, although a scriber can be used, it is far better to use a clock gauge or indicator, if possible. If one is not available, then a felt-tipped pen can be used to advantage. It must be secured in the tool post, and the work (remember we are talking of a round bar) rotated so that the pen tip touches it. A mark will, of course, appear on the metal at this point. Adjust the chuck, rub off the mark and start again. The mark should be a little longer this time. Keep adjusting until the mark goes right round the bar and is the same thickness all the way. The work is then true.

Setting up for drilling and boring is, in some ways, similar to the descriptions already given, but there are some differences. The place to be drilled must be marked out before the work, whatever shape it may be, is put in the chuck. Marking out can take two forms: a simple centre punch mark, or a scribed circle in the case of the larger hole that is to be bored. Although, it is quite possible to set up for boring large holes from a centre punch mark, and in most cases this will be the most accurate. I have known occasions when I was more concerned with the outer edge of the hole being correctly placed in the casting than with anything else. In this case, the hole was scribed in the correct place and a scriber used to get it in the correct plane to be bored. It is simply a case of careful observation that the



Where work has to be held at the edge of the jaws a piece of metal can be put behind it while setting up and this will allow the body of the chuck to be used to get it square. The metal must be removed before work starts.

scribed circle travels true to the point of the scriber, adjustments being made in the usual way.

For normal holes, a guide of some sort or another is put in the centre punch mark and the work rotated while the usual adjustments are made. The most basic form of guide is a centre suspended between the tailstock and the centre punch mark. Not all compact lathe centres have centre holes in them, however, and so some other form of device may be needed. This is known technically as a centre finder. However, most engineers refer to it as a 'wobbler' or 'wiggler', which are far more descriptive terms.

There are two versions of a wobbler: the type that goes between the work and the lathe centre. In this case, the clock gauge or indicator will be put on the wobbler as near the lathe mandrel as possible. The other type is supported between the tool post and the work. It is harder to set up in the first place but very much more accurate in use. The reading is taken at the end away from the mandrel, and so any error is multiplied by that distance. The result is a measurement to absolutely the tiniest possible movement. With the wobbler in place, adjustments take place in the same way as already described.

Once work has been set in a chuck, it should remain in position until completed. If for any reason it has to be removed,

it will have to be again checked for accuracy before more work is carried out. Undoing just two chuck jaws next to each other (say one and two) and then removing the work, replacing it in exactly the same position will give some accuracy. It is also possible to set identical components in this way. The system is far from infallible, however, and it is always wise to check the work position to make sure all is well before starting or re-starting as the case may be.

One use not generally considered for the four-jaw chuck is that of a tool holder. If a small turning tool is put in the jaws and set off-centre, it makes a nice little fly cutter. A boring bar in the chuck can be used with work mounted on the saddle. Small adjustments can be made to the jaws of the chuck to shift the tool a little at a time and so enlarge the bore.

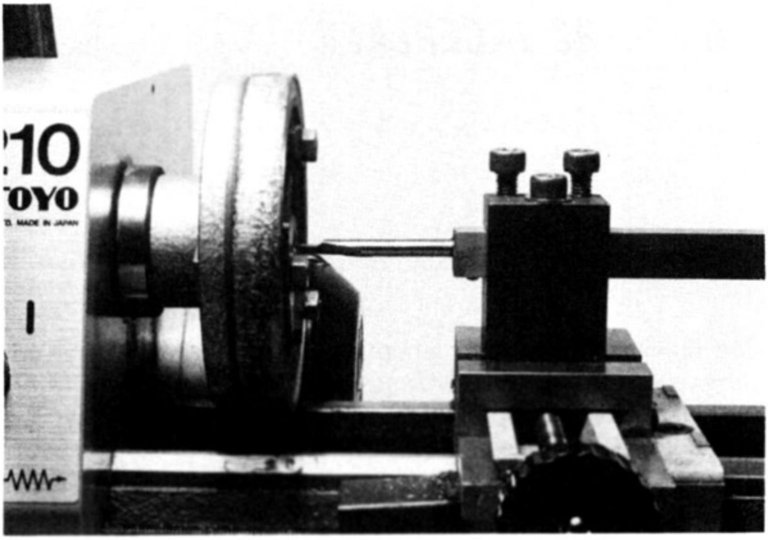
Although generally speaking four-jaw chucks are more robust than the three-jaw self-centering type, they should still be treated with care. All chucks are high-precision instruments and they will lose that precision unless looked after. The threads of the jaws should be kept clean at all times, as should the mounting area. An occasional wash in white spirit followed by oiling with a light machine oil will help preserve the chuck. All chucks should be put away when not in use, and should not be left laying on the machine to get covered with dirt and swarf.

8 THE FACEPLATE

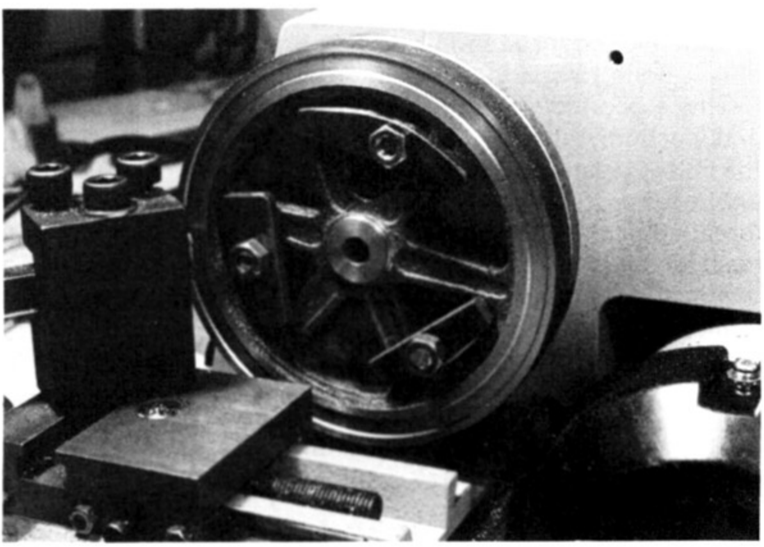
Old-time turners used the faceplate to hold work more than any other piece of equipment. These days, its use has been rather overtaken by the high-quality four-jaw chucks that are available. There are many occasions, however, when the use of a faceplate is either advisable or essential. Usually such cases will involve the machining of castings, some of which are of such awkward shapes that they cannot be held even in a four-jaw chuck.

All work will be held to the faceplate with clamps of one sort or another, and these should be secured with tee bolts. The use of tee bolts rather than ordinary bolts ensures two things. Firstly, a good location of the bolt at the rear of the faceplate and, secondly, that the faceplate will not suffer damage from the bolt. The latter point requires some explanation. If an ordinary bolt is used with a standard hexagon head, then, even if the threaded section is a good fit in the faceplate slots, the bolt head which is at the rear of the faceplate has very little metal bearing on the plate. A great amount of torque is exerted when tightening bolts, and the pressure on the plate is enormous and really quite out of proportion for that required. With just a little metal at the rear, there is a very real danger that the head will pull through and damage the slots. However, if a tee bolt is used, and laid with the longest section of the bolt across the slot, the bearing area will be much greater and so there is little risk of damage.

Some manufacturers supply tee bolts and these are usually made of square material. New ones should be made, and the tee should be, in length at least, three times the diameter of the bolt. This applies also to tee bolts used for clamping things to the cross slide of the lathe. The larger the area of head in contact, the greater the purchase of the bolt and the wider the area over which the pressure is applied, giving greater safety all round.



A flywheel for a stationary engine held on the faceplate for boring.

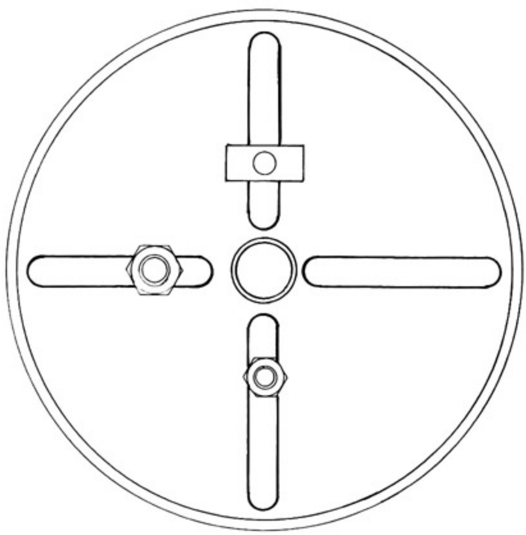


A front view showing how the flywheel is clamped to the faceplate. Note that in cases such as this a component should be secured in at least three places.

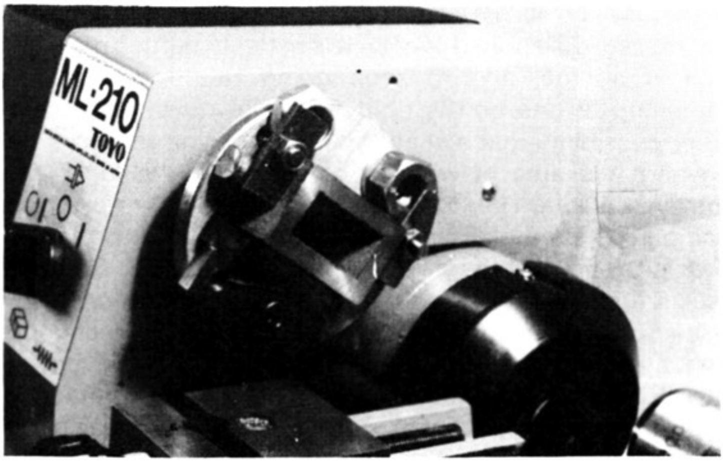
The ends of clamps that are not in contact with the work should be packed so that they are slightly higher than the end in contact with the work. This applies all the pressure downwards onto the work. A tightening sequence should be

adopted which allows all the bolts to be tightened in such a way that pressure is applied evenly. It is better to tighten each bolt a little at a time, and to keep going round doing further tightening. If one bolt is tightened right down first, there is every possibility that a slight tip will occur on the work.

Where the area of work in contact with the faceplate is uneven, packing should be inserted to level the work before clamping. Thin metal strips can be used, but these may not always be available in the right thicknesses. Cardboard packing is useful but a thin layer of cardboard must also be placed under the points where the work makes direct contact with the faceplate. The reason for this is that, if only the unsupported areas are packed with card, there is a chance that, when tightening up, these areas which are now packed will drop a little as the card compresses. If a thin card is placed



A drawing showing the reason for using tee bolts rather than ordinary hexagon headed bolts to secure work to the faceplate. The slots are eight millimetres in width. At the top we see a tee bolt with extended length. Although the actual bolt is only six millimetres in diameter there is ample support on the back of the faceplate. On the left is an eight millimetre ordinary bolt. The support is not as much as with the tee bolt. The lower bolt is six millimetres and it can be seen that there is no support whatever. The advantage to the use of six millimetre bolts in an eight millimetre slot is the fact that room is made for adjustment. It is obvious that this can only be done with a tee bolt, and although the eight millimetre bolt would just about suffice, adjustment of the position of the component becomes very difficult.



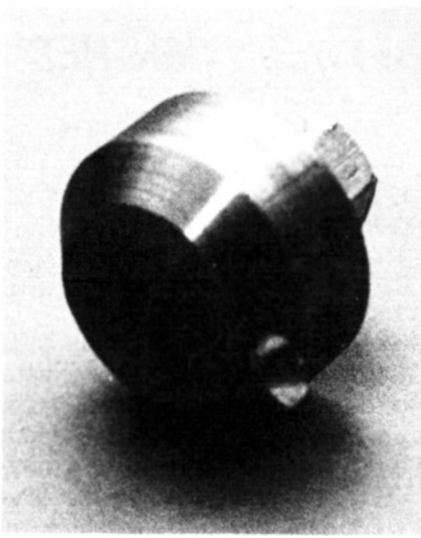
A steam chest for a two and a half inch gauge locomotive being machined on a faceplate. Note there is a securing bolt on each side gripping lugs on the chest. Nuts have been used to allow the clamps to press downwards on to these. Underneath the chest is bolted a metal bar. This acts as a support to prevent the work twisting when machined and while not actually holding the work down it takes some of the strain of the two securing bolts.

under the other surfaces as well, then all should compress at the same rate.

Mounting the work can be difficult on the compact lathe. There is very little room for one's hands, and the weight of the work makes it tend to slide down while the initial mounting is taking place. It is then better to take the faceplate away from the lathe, if possible, and mount the work on it while it is in a horizontal position. It is far easier with the work in this position to make adjustments. On some lathes, such as the Toyo, where the faceplate is held to the mandrel with allen screws, horizontal mounting may not always be practical because no room is left to get at the screws when the work is on the plate. On all screw-on mandrels, though, it is easy enough to set the work up and then screw the whole lot to the mandrel.

Care must be taken to ensure that all burrs are removed from work where it will come in to contact with the faceplate, otherwise inaccuracies will be present. Accurate setting up with the work held in the horizontal position can be achieved by careful measurement of the component from the faceplate edge. Work can be held temporarily with plasticine or more permanently with double-sided adhesive tape while setting up is done.

If work is to be held on one side of the faceplate, then a



Apart from work holding, a faceplate can be fixed with a fly cutter like this for machining flat surfaces.

counter-balance weight of some sort should be applied to the other side. If this is not done, the little lathe will be very much out of balance and will vibrate badly. There is no reason whatever why work held on the faceplate should not also be supported from the tailstock, in the same way as work held in chucks.

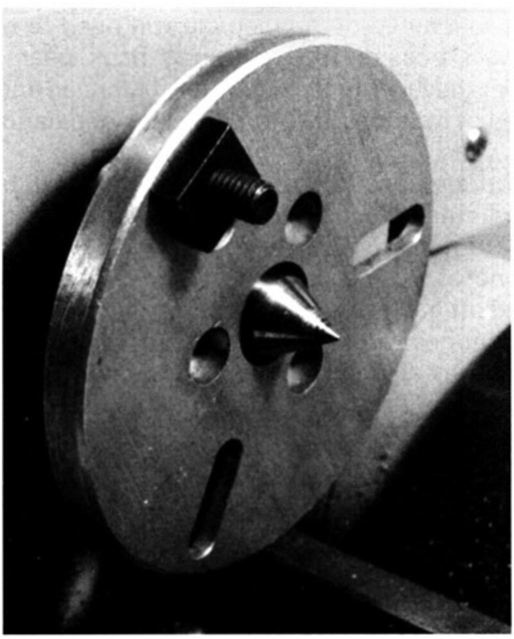
Most work that is machined on a faceplate will need to be rotated at the slowest possible speed, using back gear if available. Such work is never entirely accurately balanced and, the greater the speed of rotation, the more this lack of balance will be noticed.

For the final accurate location of work, it may still be necessary to make minute adjustments after the faceplate has been mounted on the lathe. For this, clamps should be loosened a little, one at a time, and the work tapped into position with a light soft mallet, such as a plastic-headed one. Wobblers and clock gauges can be used for setting work on the faceplate in the same way as they can be used for work in the four-jaw chuck.

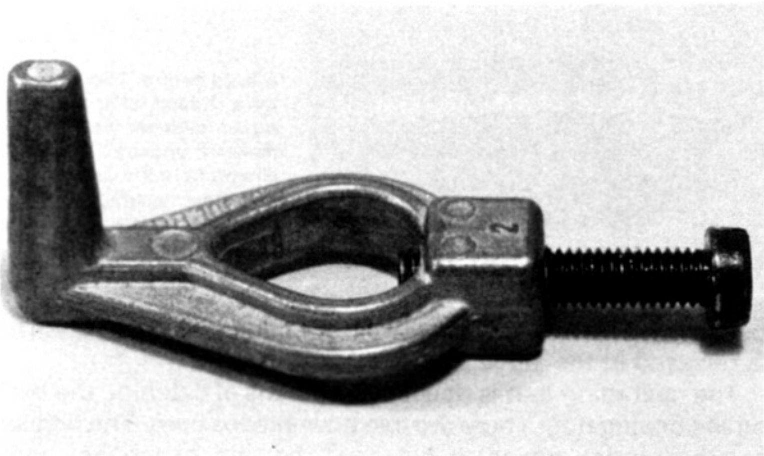
9 TURNING BETWEEN CENTRES

Before the advent of modern-style chucks, all work on the lathe was turned between centres. While with modern equipment there is less need to learn the art of doing this, there are still times when it is useful to know how to do so. For example, where we have a bar of metal that is too large for a chuck, the only way it can be supported is between centres. To mount work in this way, the lathe must be fitted with a soft centre in the mandrel and a faceplate on the nose of the mandrel. In the faceplate must be a "driving dog'. A driving dog is only a peg sticking from the faceplate, and an ordinary bolt will do this quite well. On larger lathes, special drive plates are available but, for our purposes, there is no reason why the faceplate should not double up.

To support the work at the tailstock end, either a hard-dead



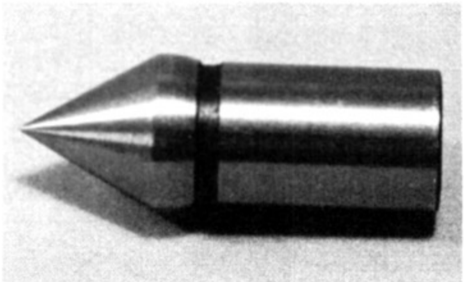
A faceplate with a bolt through the slot to act as a driving dog.



A carrier. This bolts to the work being driven. The lug, at right angles in this case, fits in the slots of the faceplate and the carrier is driven in that way, so there is no need for a driving dog. Other carriers have the lug running parallel to the bolt and that is then in contact with the dog making the work rotate. Carriers are available in a variety of sizes. If a convenient size is not to hand, any pieces of tube can be pressed into service to do the same job. Two holes are drilled and tapped opposite each other and one is used to bolt to the work, the other has a bolt fitted and this is put in contact with the dog to drive the work. If tubing is not available then large nuts will also do the job very well.

or rotating centre will be needed. It is here that wear will occur, and so the point of the centre must be well greased before work commences.

What we are going to need next is a centre indented in each end of the bar to be machined. It is almost certain that the bar will have a sawn end, and facing it to start with will be out of the question. It must then be filed as square as it can and burrs should be removed. It is not essential that it is exact at this stage. The centre of the bar must be marked off and a centre punch mark made. I should at this stage point out that, when this sort of work is carried out, it is usual to start with an oversized bar to allow for any discrepancies in marking out. The two centre punch marks must now be opened out to proper female centres. A centre drill is used for the purpose but how the actual work is done will depend on the equipment available to the individual. I have found it quite satisfactory to put the bar in a vice with soft jaws and make the indentations with an electric DIY-type drill. One with a slow speed is essential. If not, the work can be done with an ordinary wheel brace. The important thing is that the recess must be as near parallel to the

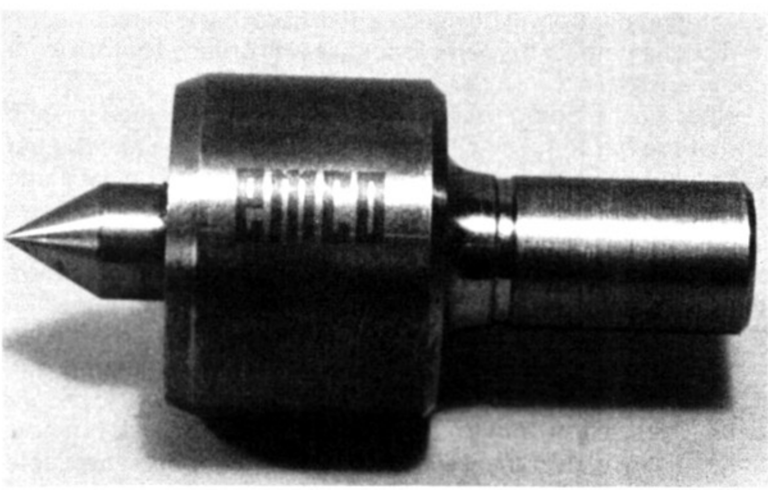


A hard centre. This one for a Unimat lathe has no morse taper and that makes it unusual. It is a sliding fit in the tailstock and there is sufficient purchase on the short taper near the point to prevent it turning.

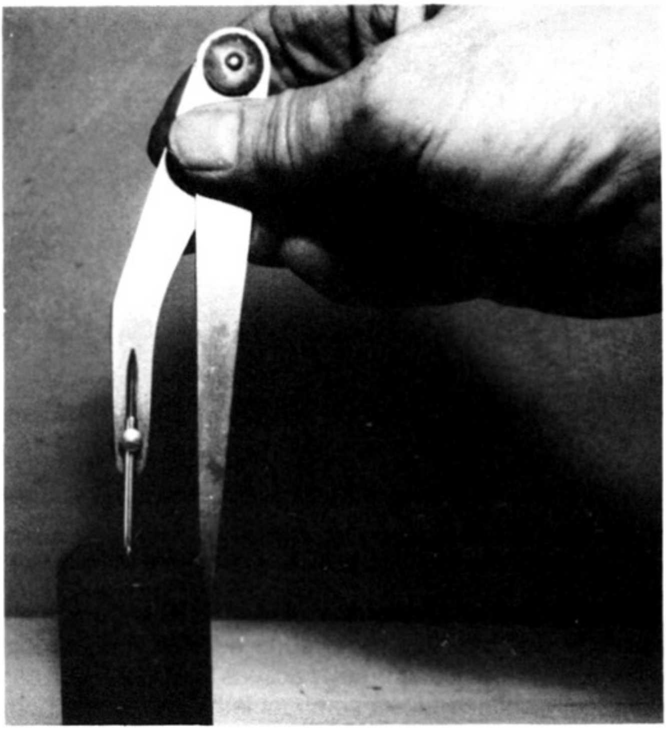
bar length as is possible, otherwise difficulties will arise when it is revolved in the lathe.

The next thing that is needed is a means of catching the bar on the driving dog. There are two possibilities here. The first is a lathe carrier, which is put over the end of the bar and tightened up. As the faceplate rotates, the driving dog strikes the carrier and it will revolve. Of course, if we put the carrier on a round bar, no matter how tight it is done up it will slip as soon as pressure is applied. It is therefore necessary to file a small flat on the bar to prevent this happening. Another way is to drill a small hole to accept the top of the carrier screw.

I prefer not to use a carrier for such purposes. Instead I drill and tap a hole in the work and put a bolt in this. The driving dog



A rotating centre, again to fit the Unimat lathe. These centres are available for all lathes and have the advantage that they do not wear as much as the hard centre. They also have the disadvantage that they are rarely as accurate as the ordinary hard centre. As they run on ball races it is possible to use them at much higher speeds that the normal dead centre.



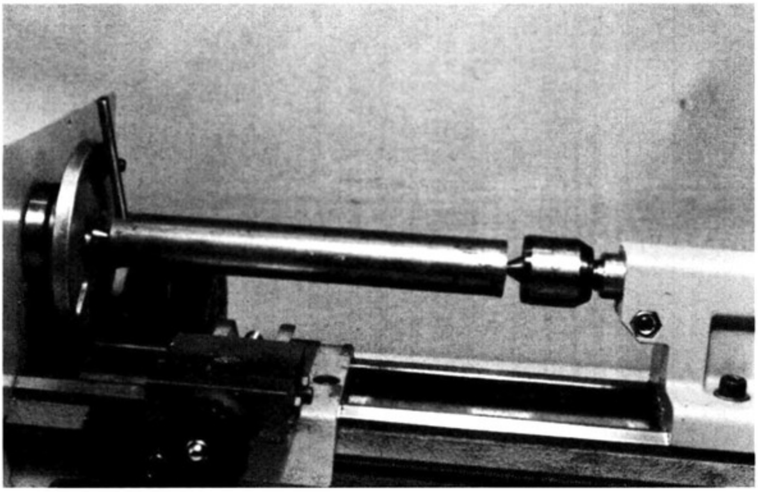
Metal to be turned between centres must have a centre marked on it. If odd leg calipers such as these are used, four marks can be made from different positions on the bar and the middle of these marks will be the exact centre.

strikes it and drives the work round. The drilled and tapped hole takes no more area of the metal than the filed section and so nothing is lost, but the drive is much more positive.

Once the work is rotating, turning can commence. The tailstock and the tailstock barrel must be locked in position, and from time to time examined in case the work has come loose on them. The tailstock centre must be kept greased.

This is a highly accurate method of turning and has the advantage that work can be removed from the lathe and replaced with no loss of accuracy, which is something that cannot be done with a chuck. The biggest disadvantage is the fact that the part held by the carrier may later have to be removed, although the same would apply to the portion held in a chuck.

Facing is difficult. A half centre can be used and this will certainly allow work to be faced at the tailstock end. It can be



Work supported between centres for machining. In this case a hole has been drilled and tapped in the bar and a peg inserted to contact the driver.

reversed to face the other end as well. A half centre is a normal dead centre with one side removed to a flat so that, although it supports the work, it allows greater access for a tool. Such centres are not easily obtained for a compact lathe and would normally have to be home-made. The obvious way to do this is to get a hard centre for the lathe and grind the flat on it. Care will have to be taken to prevent it overheating and so softening.

There may also be a problem if the centre is only case-hardened. A centre can be made from silver steel and hardened. In order to get the necessary accuracy, it is essential that it is made at one setting. A flattened soft centre is of no use whatever.

As you can see, there are problems with the method for a compact lathe user. However, there are times when it can be a perfectly satisfactory process and will be the only method which will allow work to be machined.

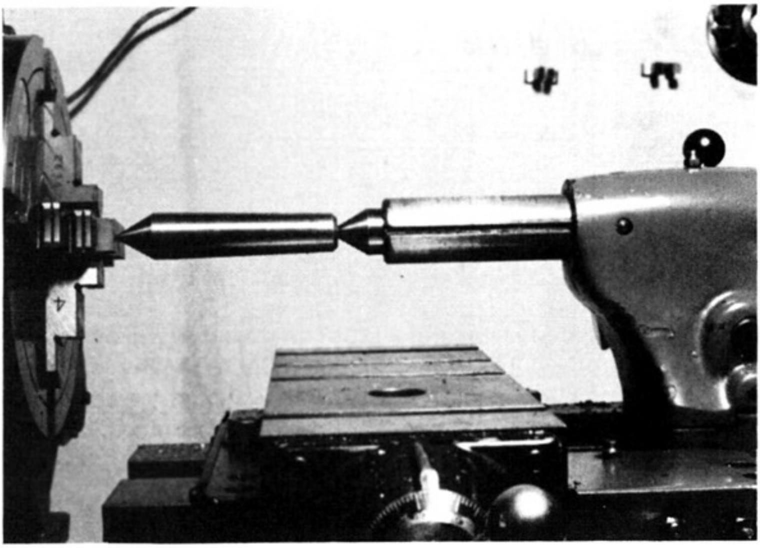
10 TURNING TAPERS

The method used for turning a taper on the lathe will depend to a large extent on the equipment available. Many compact lathes do not have top slides, and come with just the saddle for turning lengthwise and the cross slide for facing work. Usually, a top slide is available as an extra and, if this is so, then for turning short tapers such a device is invaluable.

To use a top slide for taper turning, the slide must be set to the required angle, assuming this is known. It is then just a case of setting a suitable cutting tool to centre height and going ahead. Where possible, one should work from the smaller diameter of the taper towards the larger one. The cross slide is wound in to a suitable place to start the taper and then the cross slide moved to cut the material. At the end of the cut, the top slide must be wound back to its original position. The cross slide can then be moved in a little more and the process repeated.

It is essential to return the top slide to its original position after each cut, and only light cuts should be taken. It must be remembered that, with each cut, the travel of the top slide will get longer, and so it should, in the first place, be started as far back as possible. The saddle must not be moved during operations and, if possible, it should be locked in place. There will obviously be a considerable overhang from the chuck of the material being machined and this should be supported with a centre. Failure to do so will inevitably lead to a rough finish and almost certainly lack of accuracy in the taper.

So much for using the top slide to make a taper when we know the angle that the taper will be. However, what if we do not know the angle? In this case, we must set the top slide using a known taper as a guide. I am thinking here in particular of making morse tapers for tooling purposes, the usual case where such tapers will be needed. Setting up for these is not difficult but two centres with tapers will be needed in order to do so.



To turn a known taper, set up the master taper as shown. The top slide can then be adjusted to run parallel with it and all tapers on that setting will be the same as the master.

Start by putting a piece of round stock in the chuck and putting a centre drill in it. Into that, put the point of a lathe centre and support the other end with a centre held in the tailstock. All tapers should have centres in the ends. Put a flat metal bar in the tool post at right angles to the chuck, in other words so that it runs parallel to the bed. With the top slide loose, wind the cross slide in and gradually adjust the top slide until the flat bar is touching the known taper throughout its length. It is important at this point to take the utmost care, as even the slightest discrepancy will cause the work to be well out. If a great deal of care is taken, the setting of the top slide should now be right to turn the taper. However, I like to make sure and I set up a clock gauge in the tool post after removing the flat bar, and then run the gauge along the taper. There should be no variation of the needle as the clock is run along.

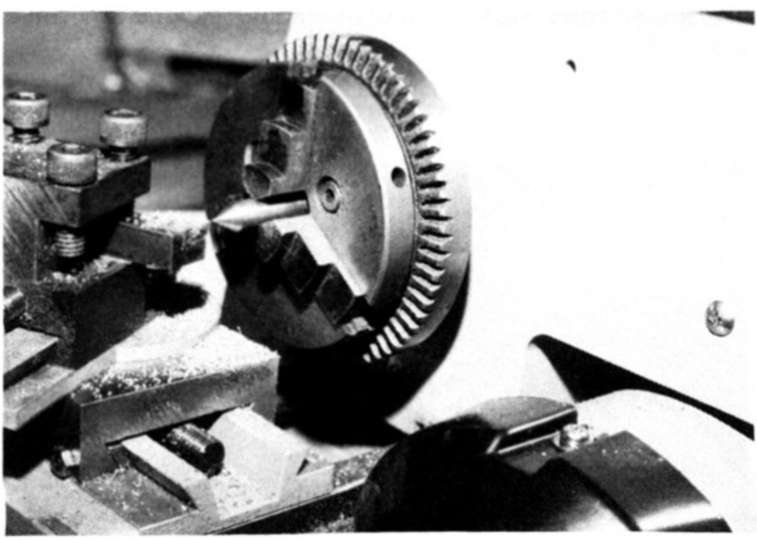
When the taper has been turned, the end should be centred. The metal can be sawn or parted off, and the taper inserted in the lathe headstock and the non-taper section finished as required.

Another method of taper turning, and one that is particularly useful where long tapers are required, is to set the tailstock over and support the work between centres. The eccentricity caused by the tailstock movement will cause a taper to be

turned. However, there are a couple of snags with this system. Firstly, not all tailstocks can be moved over and, if they can, then setting them back exactly in line to get perfect accuracy is difficult.

It is possible to use the setting over idea without actually moving the tailstock. A flat bar is centred on one side and this centre will be supported on the tailstock centre. On the other side, another centre is made at a set distance from the first centre. This can now be used to support the work. There are two ways of doing this. One is to open the centre mark out into a hole and turn a centre with a step to fit this. The second, and the one I prefer, is to use a ball bearing as a centre. There is nothing difficult about doing this. The ball is just supported between the centre in the work and the centre in the bar, and it will work in exactly the same way as a centre. I use the ball bearing method frequently for ordinary centering of work, as well as for making tapers.

The turning operation for set over work is similar to that when using the top slide. It is essential that the saddle, which is now used for turning the length of the taper, is moved back to its original position at the beginning of each cut. The cross slide is used for reducing the diameter of the material. It becomes fairly obvious that, when using this method, the small diameter must be the starting point, as any attempt to start with



Making a centre using the top slide turned at an angle, using the graduations for the angular setting.

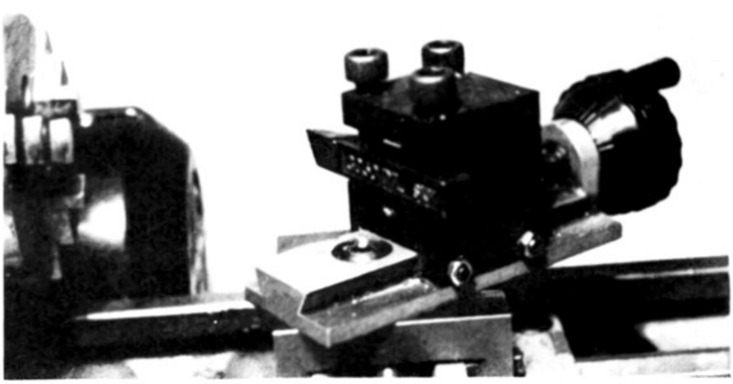
the large diameter will soon involve trying to remove large chunks of metal as the eccentric end of the work is reached.

So much for turning male tapers, but how about female ones? There is not a lot of difference really, except that first a hole must be made to a diameter just slightly less than the minimum diameter of the taper. The procedure then is the same as I have already described if the top slide is used. It is not, of course, possible to set the work over for internal taper turning, as it is impossible to support the end.

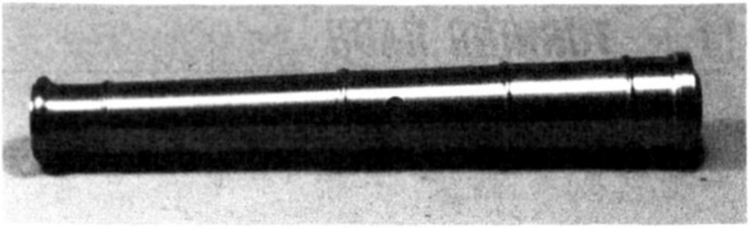
Taper reamers can be used to finish internal tapers. In particular, they are useful where internal morse tapers are made, as a good smooth finish can be obtained. Some tapers, such as those for taper pins, can be made with the direct use of a taper reamer in a pre-drilled hole. In these cases, care must be taken to remove frequently the reamer to prevent a build-up of both heat and swarf and, although reaming such holes is fairly straightforward on brass, it is not always so easy where harder materials are concerned.

If there is a need to make matching male and female tapers, then one top slide setting only should be used. First of all, turn the male taper or tapers as the case may be. Next, turn a male taper on a piece of silver steel of suitable diameter. File the taper section flat to exactly half its diameter, and harden and temper it to a dark straw colour. The flat section should be lightly honed on the top to give a nice, sharp edge. You now have an efficient taper reamer matching exactly the male tapers previously turned.

All the above assumes that the taper will be turned with the small diameter furthest from the lathe headstock, and that the



The top slide set over for taper turning. The graduations on the handwheel which are clearly visible here, must be used to ensure accuracy.



A typical example of taper turning is this model gun barrel. To make this, a suitable diameter bar can be set in the three-jaw chuck. Turning can commence from the small end - a setting of only one and half degrees was required. The ridges on the barrel were finished with a small form tool, the barrel being supported by a centre during this operation to offset the heavy sideways thrust caused by the use of the form tool.

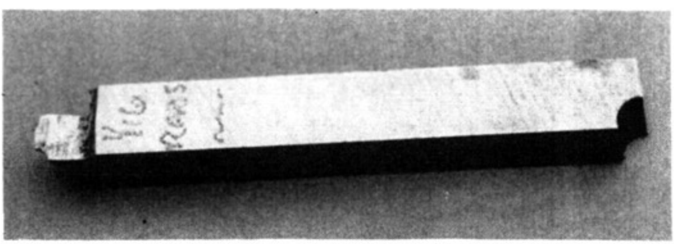
small diameter of the taper will also be the end of the work. Or that the work end will not be larger than the small diameter. Occasionally things do not work out quite like this and it is necessary to turn the taper the other way round, leaving it with a step at the small end so that the metal is larger than the minimum diameter. In these cases, a parting tool should be used to cut a groove into which the tool turning the taper can be run during operations. If this is not done, an uneven finish on the stepped section will be the result.

The tool used for turning tapers should be similar in shape to those used for screw cutting. If we stop to think about it, this is fairly obvious as screw cutting consists of turning a whole series of tapers in vee shape along the length on the material. A slightly rounded nose will assist operations and help to obtain a smooth finish to the work. As in all operations, the use of the correct lubricant will also help in obtaining a good finish.

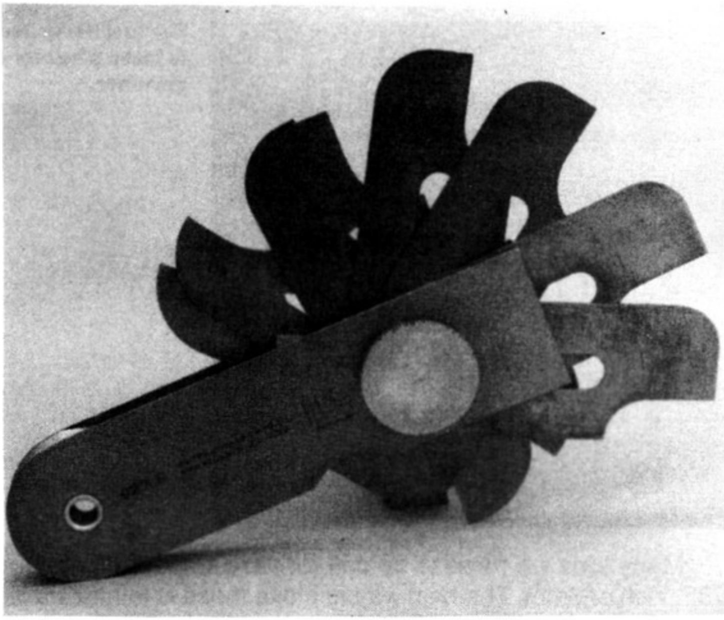
11 TURNING RADII

At some time or another, there will be a need to turn radii of various sizes, and I propose to deal with that in this Chapter. Our machine has built-in facilities for running the tool along the length of the work, and across the face of it. In Chapter 10 it will also be seen that it is possible to turn at an angle, however generating curved surfaces calls for other methods which are not allowed for by the machine.

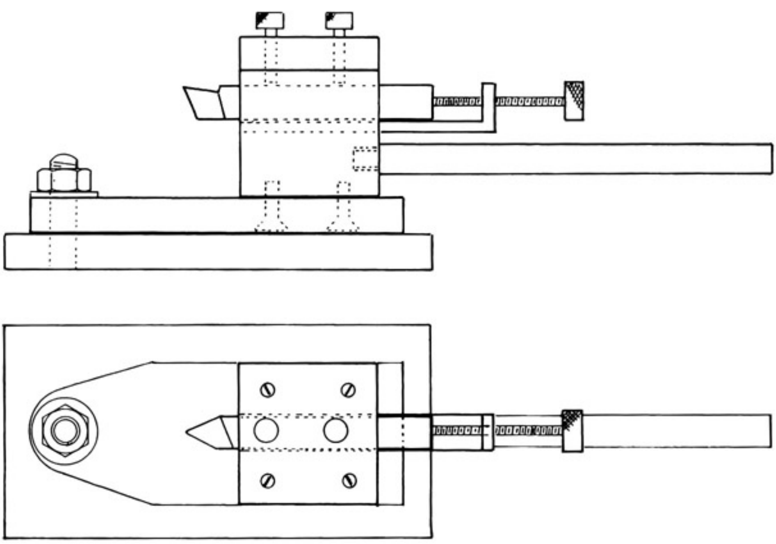
It is possible to make a radius either concave or convex by careful manipulation of the saddle and cross slide at the same time. It is an exercise that calls for considerable dexterity but, with practice, quite an acceptable curve can be made in this way. To get it right, it is necessary to know one's machine well, so that a judgement can be made of how many turns of the cross slide are required to those of the saddle. By using the graduations, it is possible to work out beforehand how many turns on each are needed to get the radius needed. In the past I have had to resort to this method, and I used to work it out on graph paper. I must confess I soon abandoned the idea for easier methods, as I found it difficult to turn the cross slide with my left hand while turning the one to operate the saddle with my right, and to keep both going at the same ratio, say, two movements of the cross slide to one of the saddle.



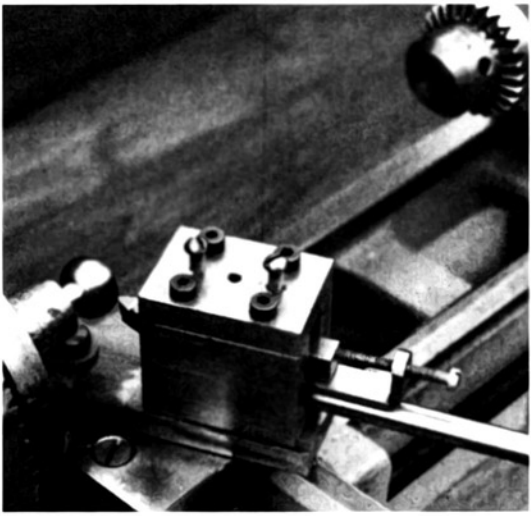
A form tool for turning outside radii. A different radius is at each end of the tool and each on a different face of the metal. The radius has been marked on the tool by etching with acid, thus ensuring that it is available for future use.



A radius gauge. Each section is a different radius and has both outside and inside radii. It can be used for making tools and also for checking radii on work.



The drawing of a simple radius and ball turning tool. It can be made to dimensions to suit individual lathes.

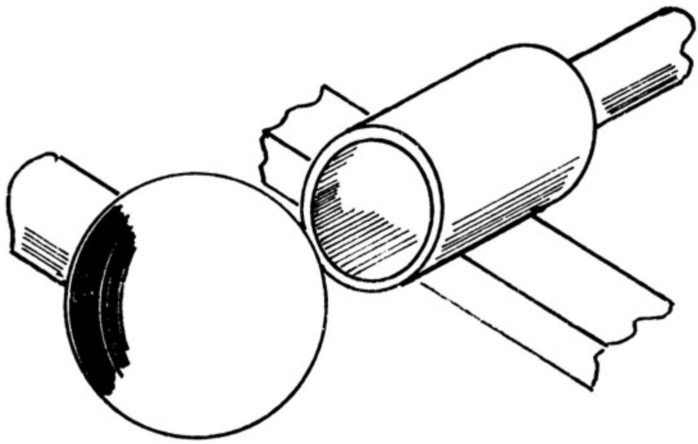


The tool being used to make a ball for a governor.

Many jobs we need to do call for very small radii of about 1/8th inch or 3mm. The best way to make these is to make a tool specially for the purpose. Such tools should always be retained for future use. I now have quite a collection and small radii are no problem. In an ideal world, we would make these tools by grinding them from high-speed steel, but this is far from easy. It is a good idea to make up a small rectangular holder, as with a boring bar, or use one already made for that purpose and fit the radius tools in that. The tools can then be filed to shape from silver steel and hardened and tempered, all such tools being tempered to a light straw colour. To ensure the correct radius, make a cardboard template and fit this to the tool. It will still be necessary to have a side and top rake for clearance purposes. It is possible to purchase radius gauges to assist in the making of such tools, and the professional engineer would always use one. However, they are expensive and a cardboard template will make a very good substitute.

Larger radii create their own problems. On soft materials, such as brass, they can be made by hand, using a hand rest. The clockmaker always makes them in this way.

We can also make larger radii by using specially made tools. These are quite simple and consist of a tool post on a pivot. The tool has to be micro-adjustable and for this we can use an ordinary bolt. The actual operation of the tool is still by hand but, because the tool itself is pivoted and secured by the pivot, less skill is needed than in the case of hand turning. It must be remembered that, when making such a tool, the material from

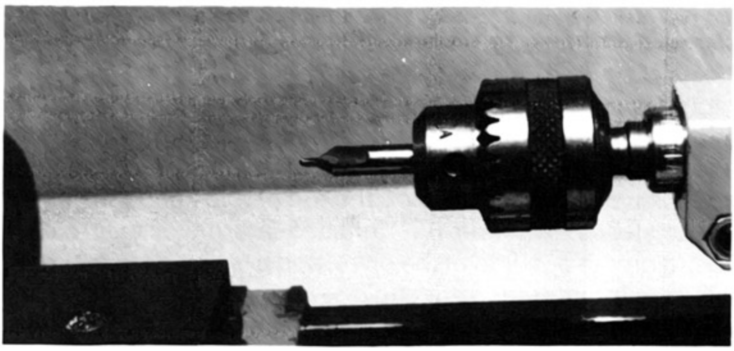


A section of tube, hardened and honed, fitted to a handle and used on a hand rest makes an ideal tool for turning radii on soft metal. This type of tool is used extensively by clockmakers.

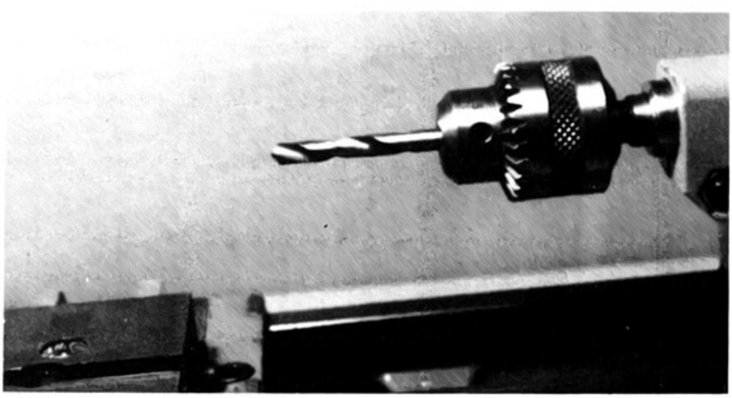
which it is made must be adequate to take the strains that will be involved as the tool bites into the metal. In particular, the pivot should be made of as large a diameter as practical, and a large diameter washer used on the top of it to keep the bearing surface steady. Whether the radius is internal or external will depend on the position of the pivot, and it is as well to make two tools, one for internal work and one for external. A tool that will do both, while quite practical, is somewhat more difficult to manufacture.

12 DRILLING AND BORING

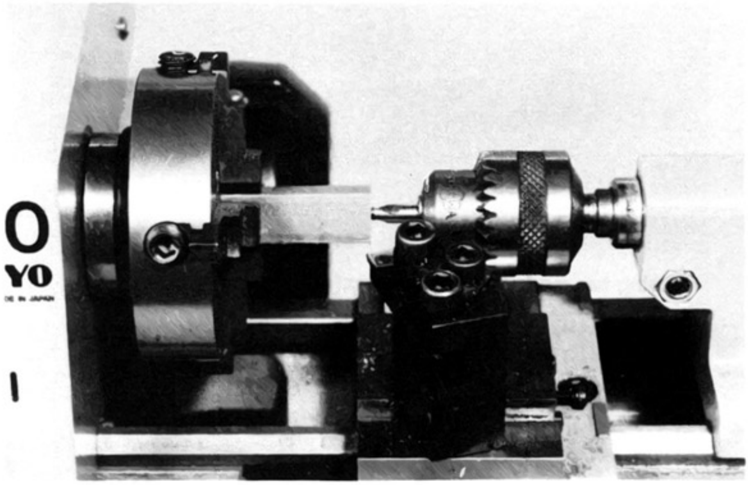
The subject of using the compact lathe for the purpose of drilling and boring can be looked at in two ways. One is drilling as part of the operations involved in turning the work, and this will include boring as well. The second is that we can drill work with a drilling/milling attachment bolted to the lathe, which



All holes, no matter what the size, should be started with a centre drill.

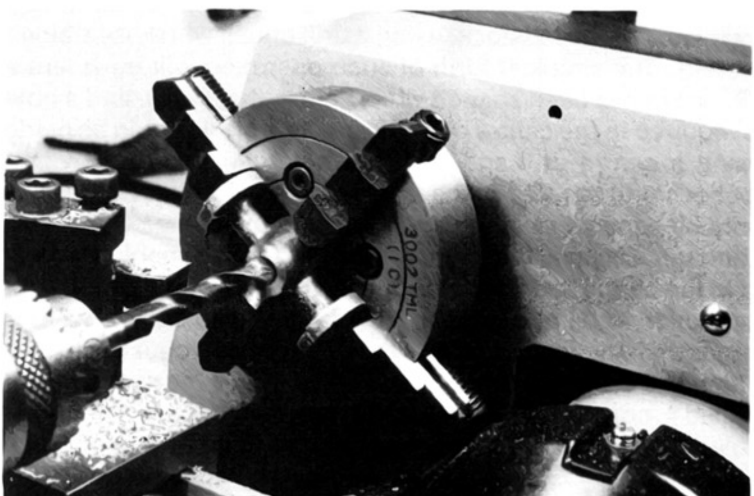


A stub drill set in the tailstock chuck. Note the short length which makes it ideal for use on a compact lathe.

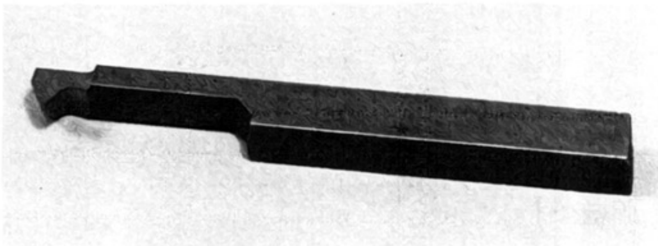


A hole is started with a centre drill in a square bar held in a four-jaw chuck.

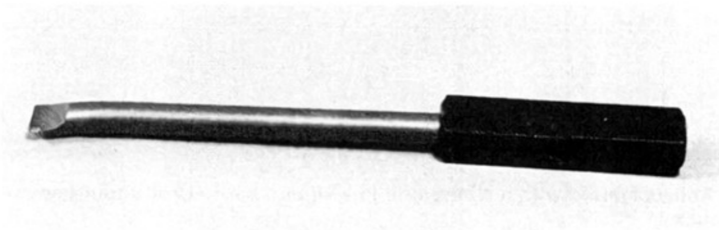
may well include such operations as drilling sheet metal. Using the drilling and milling attachment is dealt with later in the book, and the sort of drilling which is done using the attachment is also explained in that section. I propose to deal here with the actual use of the lathe for the purpose of drilling holes in work that, in all probability, is having other operations



A normal length drill being used to drill a component. The extra length of the drill is likely to lead to it wandering off line.



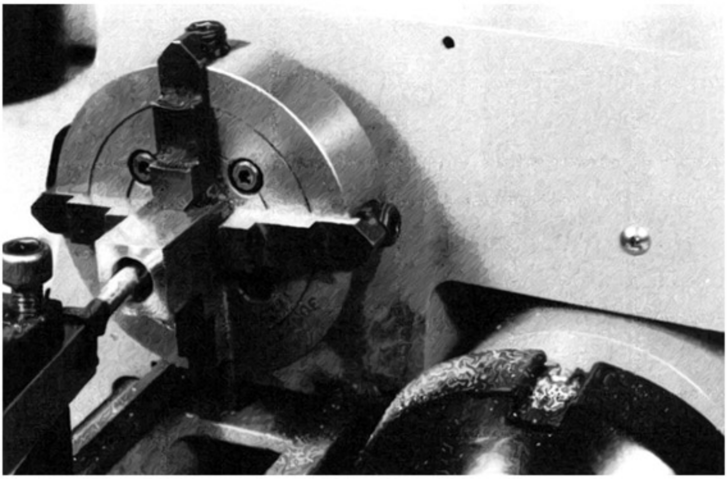
A boring bar made from square bar.



A boring bar as supplied for the Unimat lathe. The tool is very small and is held in a holder made from a piece of drilled square bar. The hole is sliced along its length and when the tightening screw of the tool post is done up it holds the boring bar securely in position. Similar holders can be home-made and will hold very tiny boring bars made from broken taps.

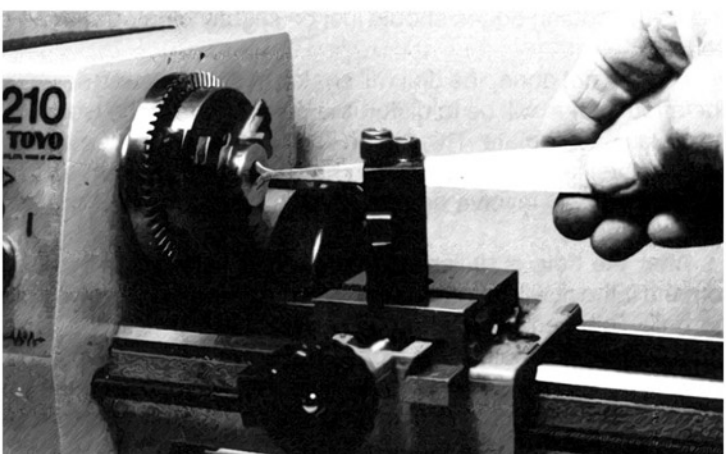
carried out on it, and where the drilling is only one of the operations. This, then, will also cover boring.

Work mounted in a chuck or on the faceplate can be drilled by means of the tailstock, using a drill chuck which is retained therein. The simplest form of such operation will be where a round bar has been shaped while held in the chuck, and a hole is required in the centre of it. To do this, a start should be made using a centre drill and then the hole can be drilled with a jobber's drill secured in the tailstock. Most compact lathes will only be capable of using a $\frac{1}{4}$ inch or 6mm diameter drill and, although it is possible to get drills with stepped shanks that will fit in the chuck and so enable one to drill larger holes, this is not a practice to be encouraged. It is far better to bore any holes larger than the maximum size that the tailstock chuck will take. There is a school of thought that holes will be more accurate if drilled progressively. For example, if a $\frac{1}{4}$inch or 6mm diameter hole is needed, start with a $\frac{1}{8}$th inch or 3mm drill, then use a $\frac{3}{16}$th inch or 4.5mm one, followed by the finished size. This method certainly makes hole drilling far easier and imposes less strain on the lathe but, while on larger lathes it is quite suitable, on the compact lathe it may not be the best method.

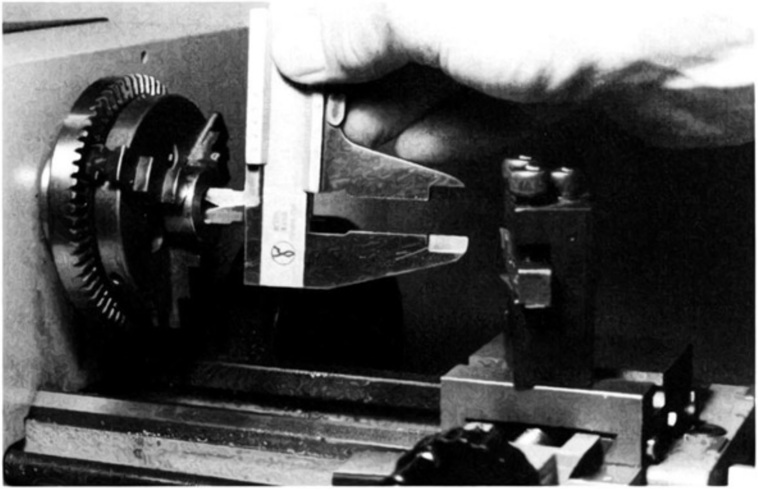


A boring bar being used to bore a hole. Note that it is set at a slight angle to get clearance through the whole length of the bore.

How effective the method is will depend to some degree on the depth of the hole. Where deep holes are drilled, there is always a tendency for a small drill to wander off line, as small diameter drills will bend when put under pressure. Once a drill has done this, then any other sizes put through the same hole will follow exactly the same path and so will also finish up out of true. A deep hole can be regarded as anything in length of more than three times the diameter of drill being used, and in these



Using inside calipers to check the size of a bored hole.



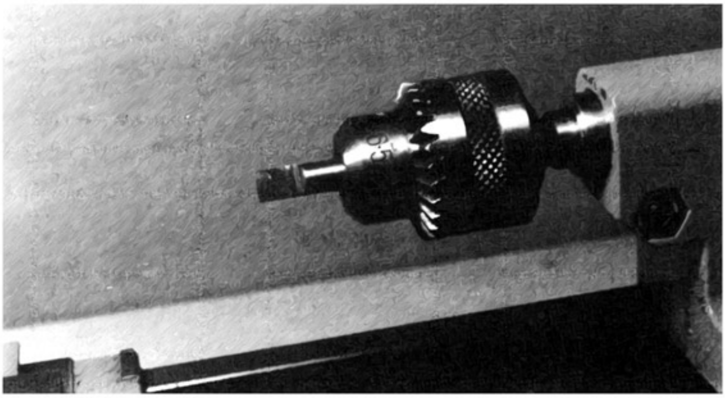
Using the back of a vernier gauge to measure the bore of a hole. If extreme accuracy is desired, a piece of bar to the exact diameter of the hole should first be made and this pushed into the hole. There should be no sideways movement on the bar, which is known as a plug gauge. Very accurate ground plug gauges can be purchased.

cases the full-sized drill only should be used. The load imposed on the lathe by using such a drill can be eased by slowing the speed of the work, and also by feeding the drill very gently without forcing it in any way. When drilling metals such as brass, copper, gunmetal and bronze, the drill should be specially ground to suit the purpose. However, in such small sizes this is rarely practical, and so the cutting edges should just be slightly blunted with an oil stone.

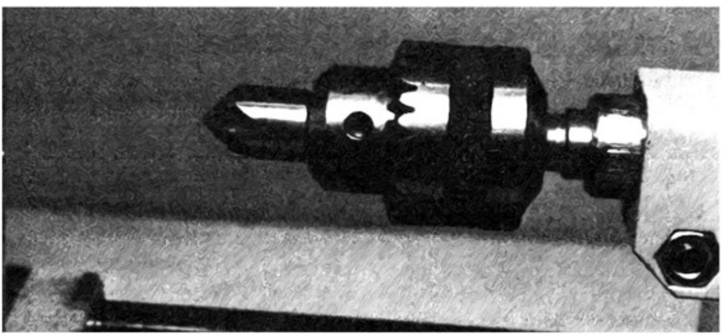
If this is not done, the drill will snatch in the work and seize up. The affect of this will be to distort the hole or to tear the work from the chuck or faceplate. This action itself can severely damage the work, as well as being somewhat hard on one's temper, as in all probability it will involve completely re-making the part that has been damaged.

After the hole is drilled and when the work can be removed from the lathe, it will be necessary to remove the burr thrown up by the drill. This can be done usually by holding a drill of a larger diameter than the hole in the work, in a gloved hand and rotating it on the burr. Particularly obstinate burrs may have to be dealt with by putting the work on a drilling machine or attachment and rotating the de-burring drill under power.

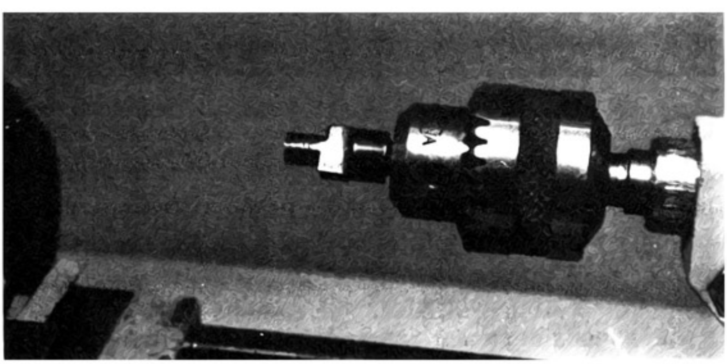
The advice contained above will suffice for all holes of a small diameter drilled centrally through the work. Where the



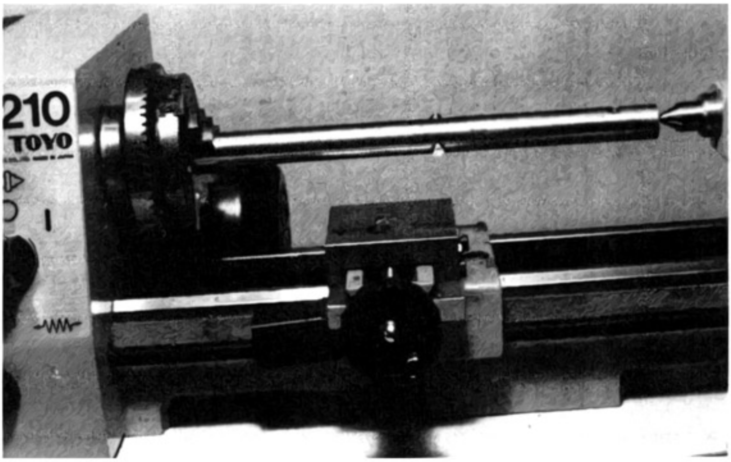
A home-made 'D' bit which can be used for getting blind holes square at the bottom.



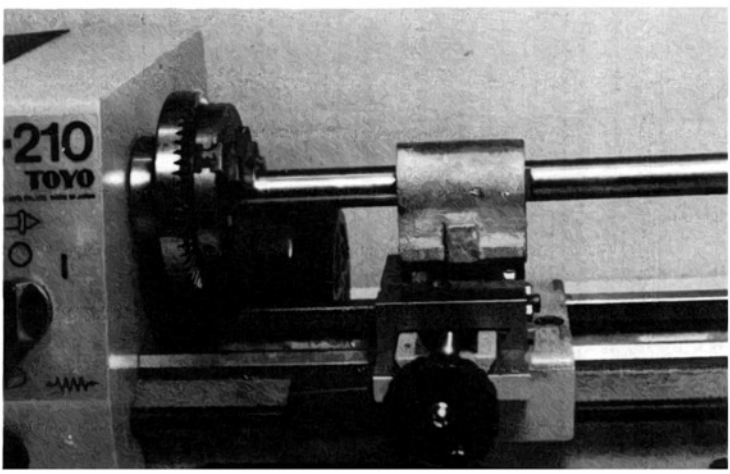
A countersink, used when angular recesses are required.



A counterbore. The pin fits the hole which has been made, the flat section has two cutting edges and cuts a hole to accept a component or part thereof.



A boring bar set in a three-jaw chuck and supported with the tailstock chuck.



Showing how the boring bar can be used to machine a component. The component must be thoroughly secured to the cross slide while machining is taking place.

hole to be drilled is off-centre, then it will be necessary first of all to mark the position of the hole with a deep centre punch mark. The mark can be lined up centrally with the work held in a four-jaw chuck, and using a wobbler or centre finder, in conjunction with a clock or similar gauge, to get it true. There is often a temptation to drill such holes with a drilling machine or attachment but any hole will be far more accurate if drilled in a lathe.

Sometimes the work may be too large to hold on the mandrel, even on a faceplate. However, the accuracy of the lathe can still be put to use in such cases by bolting the work on the saddle or cross slide and putting the centre drill and subsequent drill in the lathe three-jaw chuck. This method also allows the use of much larger drills than we normally associate with the tailstock. Care must be taken in this case to ensure that the work is absolutely secure, and also there must be no attempt to force the drill through. It is important that the drill is allowed ample time to cut the metal.

Where larger holes than can be obtained with a drill are needed, boring must be resorted to. The hole is first started with a drill and then a boring bar passed through, cutting on one edge of the inside of the hole. Several passes of the bar will almost certainly be needed to enable the hole to be brought to nearly the correct diameter. The final cuts should be such as to remove the absolute minimum of material. The very last setting of the boring bar can be used to finish the hole to a nice smooth surface. Again, several passes without altering the tool setting is advised. Small boring bars do tend to bend or whip when they enter the hole, and this will result in a hole that is not parallel unless several passes of the tool are taken on the same setting. It is important that boring bar cutting edges are set exactly at centre height to get a good finish. It sometimes helps to set the bar at a slight angle in order to obtain clearance throughout the length of the bore.

Countersinking is carried out in order that a screw, rivet or similar item may be allowed to lie with the head flush with the surface of the work, or even slightly below it. Ideally, a proper countersink should be used for the purpose, and these can be obtained with angles of sixty or forty-five degrees, in order to accept commercial screws. The countersunk section should be sufficient to allow the component to lie in exactly the correct position, rather than allowing it to go too deep.

Counterboring is similar to countersinking, except that the base of the large part of the hole will be at ninety degrees to the bore. It is used when it is necessary to set screw heads below the work surface. The obvious situation is in the case of cap screws. Counterbores can be made specially for the purpose from silver steel, or good tool stockists will be able to supply them in the correct sizes for standard screws. Holes that have been bored, because they are too large for a drill, can be counterbored with the boring bar.

All twist drills have a point on them to enable them to cut

correctly. Usually this is 118 degrees overall. Sometimes it is necessary to make a hole with a flat bottom to it. In this case the hole is drilled in the normal way and finished with a special cutter. Most people use what is known as a 'D' bit for this purpose, and these are usually home-made. The same effect can be obtained by using an end mill if the correct size is available.

Drilling and boring operations are straightforward enough. Like all machining operations, a little cutting at a time is far better than trying to work too quickly, so overstraining either the machine or the tools.

13 THREADING WITH TAPS AND DIES

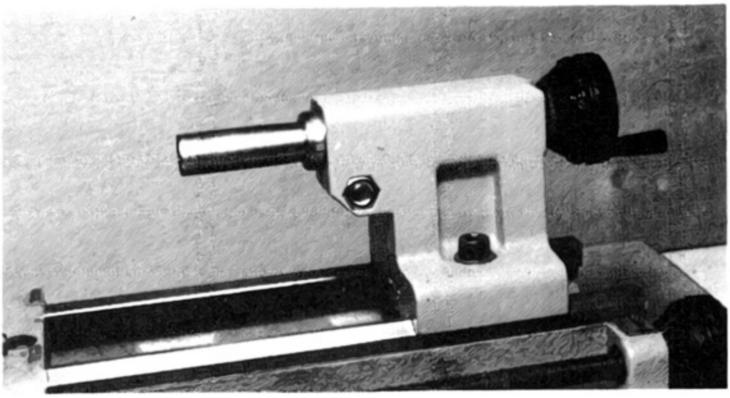
Whatever purpose for which the compact lathe is to be used, almost inevitably threading of some form or another will be needed at some time. There are two types of threads: internal and external. Internal means what it says – a thread inside a hole – and we meet this situation in nuts etc. External threading, again, is self-explanatory and we find external threads when we get bolts, screws etc.

Although nuts and bolts are the obvious things for which threads are required, there are numerous other situations where the need for threads will arise. They are used for two purposes: joining components together, and driving machinery. A typical example here is the bench vice where a screw is used to tighten it up. That screw is, in fact, driving the loose jaw. Our lathe has several examples of screw threads in its construction. The various slides are all operated with screws and frequently the tailstock is also. It can then be seen just how important threads are and how frequently we will need to make them.

We can either cut threads with our lathe by using the built-in drive system, or we can use taps and dies. The latter is possibly the more common way of doing things but it does mean that special tools are needed for each thread. If the lathe itself is used for screw cutting we need little more than a specially ground tool, but we will need some knowhow in either case.

Taps are used to cut internal threads and they come in various forms, depending on the material being tapped and the speed with which the thread is to be made.

Various types of taps are available. For our purposes we need only use ordinary engineer's taps. Even here, though, there is some diversity. Taps come as taper, second and plug. The taper is used for starting the thread, the second continues the work, and the plug (sometimes called a bottoming tap) is used for finishing. For most purposes we can dispense with the



To make a tailstock tap holder first make a section to fit in the tailstock.

second, and use a taper to start the hole and the plug to finish. Sometimes if a screw needs to grip very tight at the end of its thread, then we may even just use the taper type.

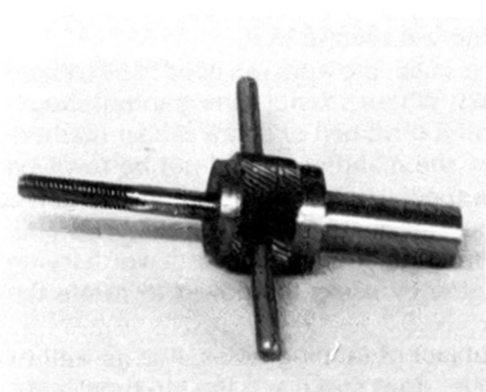
As the name suggests, the taper tap has a slight taper at the start of the thread. This enables it to enter the hole easily, as well as to get the tap in the hole straight. It is quite surprising how taps have a habit of wandering off line and going into the work at all sorts of odd angles. The plug tap is nearly, but not quite, square at the bottom and feeds into the tapered hole already made. Sometimes even the flattish bottom of the tap is not quite suitable for what we have in mind and may need grinding to get the thread right to the bottom of the hole.

It is not the purpose of this book to deal with tapping work on the bench but no doubt readers will find the information given here will stand them in good stead for such work. To use a tap successfully, the first thing we need is the correct sized hole. Having said that, there is some leeway allowed. Threads are described by their degree of engagement. Thus a hundred percent thread means that the individual threads are one hundred percent to size. The resulting thread will be very tight, and such threads are ideal where water or gas fittings are being made as the good fitting thread will prevent a leak. In many instances, we can use an eighty-five percent engagement and it will be quite successful and perfectly adequate for the job in hand. For most home machinists, somewhere around eighty-five to ninety percent is the usual engagement as this will suit most purposes and most charts give drill sizes to suit this. Our hole, then, which is to be tapped must have the correct sized hole according to a recognised chart and must be accurately

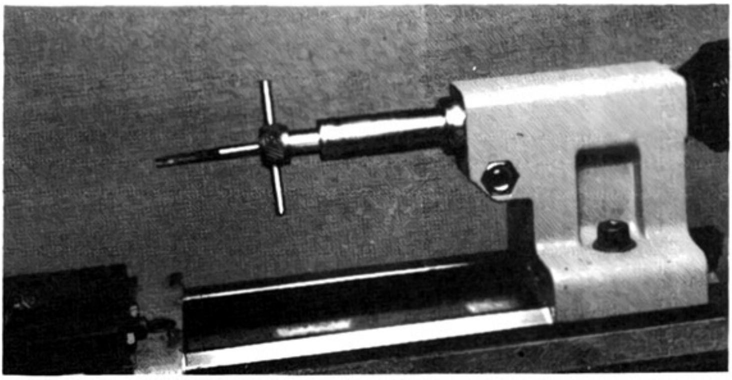
placed and perfectly square. Care must be taken when drilling it to ensure that there is no shake or wander either by the drill or by the work.

The tap must be slowly wound into the hole which, if possible, should have a very tiny countersink on the top to assist the entry of the tap. A good lubricant should be used when tapping steel, stainless steel or copper but not on brass or cast iron. After every half turn or so of the tap it should be reversed to release, otherwise it will tend to become bound up with swarf. If it is at all tight do not force it, but very gently turn it in alternate directions until it comes free. Frequent cleaning of the threads and flutes of the tap will help prevent it catching up. When used to tap work held in the lathe, the tap must be held in a support on the tailstock; trying to hold the tap in a wrench and tap such work is courting disaster. On larger lathes, it is possible to use the hole which acts as a centre in the tap in conjunction with a wrench and the tailstock centre. As a rule, this cannot be done on a compact lathe. The obvious support is the tailstock chuck and this can be used successfully. For obvious reasons, the tailstock must not be fully locked in position but should be tightened sufficiently to prevent it tilting, while still allowing it to slide easily forward.

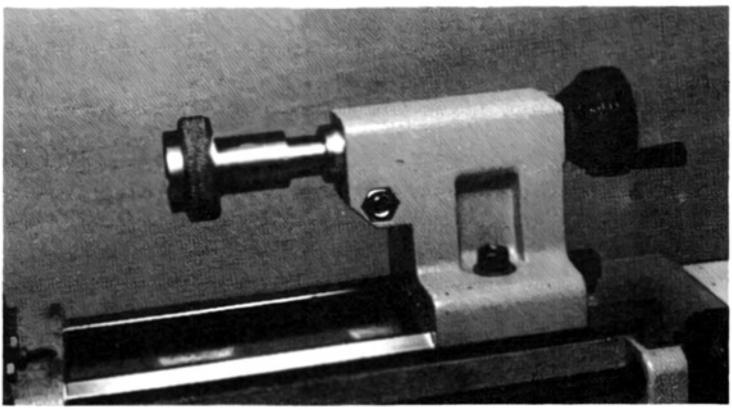
The tailstock drilling chuck is on the rigid side for this sort of work and it is better to make a proper tap holder to fit the tailstock. The shanks of taps come in a variety of sizes and a holder will be needed for each one, but such holders are very simple to make and will amply repay the time taken in so doing. Not only are they convenient but there is far less likelihood of breaking taps when they are used in proper holders. An alternative to specially-made tap holders is to use a pin chuck



The tap holder is simply a bar of metal with a hole to take the tap and a grub screw to secure it in the bar. The knurled head and cross bar are to enable a grip to be obtained.



The tap holder in the tailstock support.



The same tailstock support used for a die holder. While the tap holder fits inside the support, the die holder runs on the outside.

of the type used for holding small drills. A problem that may arise here is that the chuck grips on the round shank and, as a result, sometimes the tap will revolve in it.

If the tailstock chuck is used, the work will need to be rotated while the tap is stationary. Where possible, the mandrel should be released by taking off a drive belt or some similar method. There is no reason why the mandrel should not be revolved when the tap is held in a special holder, but tapping is largely a matter of feel and it is much easier to feel when it snags up if the tap holder is rotated. Under no circumstance is it worth trying to tap on a compact lathe by using the power to rotate the mandrel.

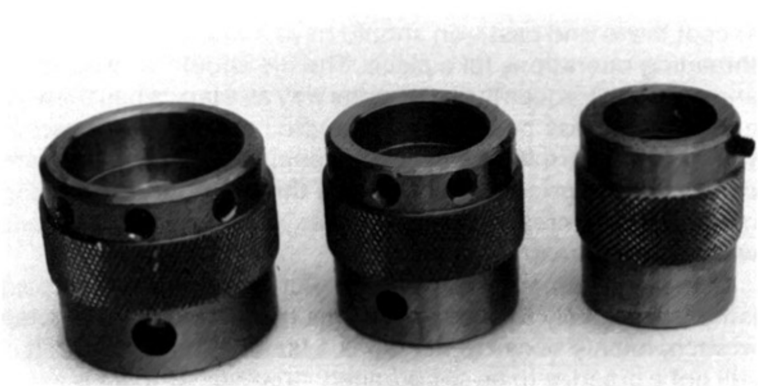
Before leaving the subject of tapping holes, it is as well to know what to do if disaster does strike and the tap breaks. As

far as the tap itself is concerned, then it will depend on the place where it has broken. If it is a tiny piece at the tip, the tap can be carefully re-ground and then re-used. To do this, follow the pattern on another tap, which will show the correct angle and also the way the back of the threads are ground away for the purpose of relieving the strain. Do not throw the tap shank away, as it can be used to make a number of tools such as small boring bars and tiny single point cutting tools.

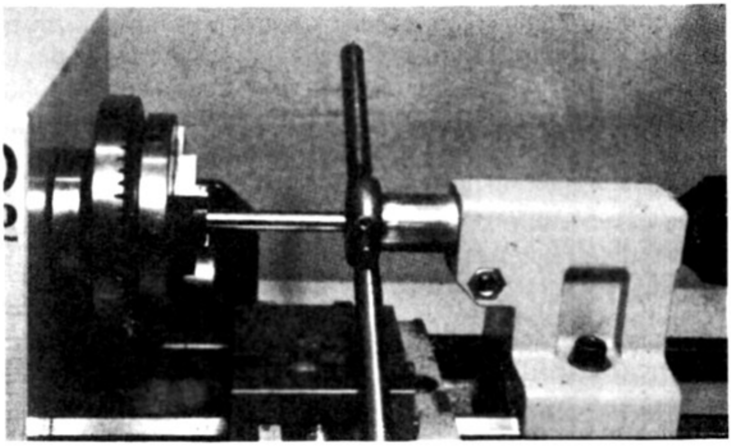
The work itself, with our piece of tap lodged in it, is more of a problem. If the tap section is stuck in either steel or cast iron, and if it is a long length it may be that there is no remedy. If the hole being tapped goes right through the work, remove it from the lathe and, by brute force, hammer it out with a punch. Open the hole out to about four times its original size and tap it. Turn and thread a piece of the same metal and screw it in sealing it with an adhesive such as 'nut lock'. The work can be returned to the chuck and re-machined, drilled and tapped, a little more carefully this time.

Taps broken in brass, bronze and copper present no great problem. Remove the work from the lathe and soak it in a solution of alum. About a teaspoon of powder to a large cup full of water is needed. Leave it a couple of days and the broken tap will dissolve, and the original hole will still be in a good condition allowing the thread to be completed.

For putting on external threads we can use dies. These are fitted into special holders, sometimes called stocks, and run onto the work as it is revolved by hand. Any die of reasonable quality has three indentations in it. One of these goes right into the split in the die and the others are either side of it. Screws in



A set of three die holders by Cowells, they fit on the tailstock barrel.



An ordinary diestock and die being used to make a thread. To ensure the die is square to the work, the stock is supported by the tailstock.

the holder fit into these indentations. Adjustment of these screws allow the die to open slightly and close, giving a small variation in diameter. The first run of the die should have the screw wound hard into the slot to give the largest possible diameter. The thread diameter can be measured and examined to see whether it is correctly formed or not, and the die adjusted and re-used until the thread diameter is correct, and the form right.

To start with, the work must be turned to the correct diameter of the thread otherwise a good thread will not be made. Only in the case of copper should the measurement be changed. As copper tends to spread when worked, it can be left a couple of thousandths of an inch undersize and the spreading will make up the full diameter. As in the case of tapping, all materials except brass and cast iron should have a lubricant used while threading operations take place. The die should be wound on and released frequently in the same way as a tap. While there is, naturally, far less possibility of the die breaking than there is with a tap, failure to release and to supply sufficient lubricant can result in serious defects in the thread. Apart from being ragged, such threads will often tear, leaving small sections without any threading at all.

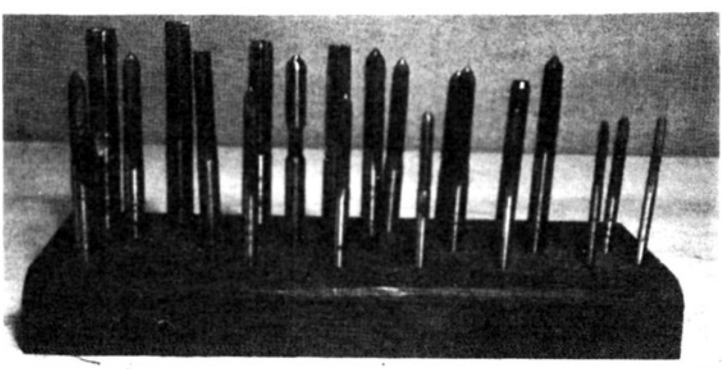
Using an ordinary die stock on work held in the compact lathe is less likely to cause problems than using a tap in a tap wrench, mainly because the tap is a far more flimsy affair. It is still not a practice to be encouraged, however, as there is every chance of getting the thread at an angle instead of at ninety

degrees. Some form of support to keep the die square then is desirable and, if the die holder or stock is supported against the tailstock barrel, this will help considerably. It must be kept under pressure all the time the thread is being made in order to get the best results.

As in the case of a tap, it is far better to use a proper die holder to hold the die. These can be purchased from suppliers of the lathes or are fairly easily home-made. The use of such a tool ensures absolute squareness to the thread being cut. The fact that a die holder is in use, however, means that care must be taken. All the faults, such as ragged and torn threads, will still occur unless there is sufficient lubrication and the die is frequently released from the work.

Finally, how can we get and look after our taps and dies? There are two types of material from which they are made – carbon steel and high-speed steel. The fact that a tool is made of high-speed steel does not mean that it will work faster than a carbon one. High-speed steel will, however, outlast carbon steel many times so, if we need a tool to make threads that we know will be used frequently, then high-speed steel is the answer. If we are certain the tool will only be used a few times, the much cheaper carbon steel will do. Carbon steel will last for quite a while when only brass is being threaded, but bronze will blunt such tools easily as will mild steel. If a thread is to be put on a tough steel, such as silver steel or gauge plate, then even for a single thread, it is unlikely that a carbon steel tool will be successful.

All good tool stockists and model engineering suppliers will be able to supply taps and dies. It is worth looking round at car



Taps should be kept in such a way that they will not rub against each other and so become blunt. These are in a wooden block.

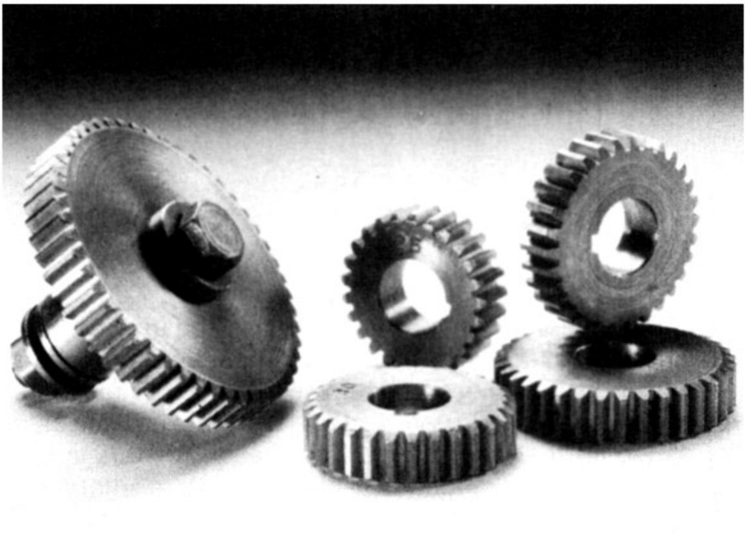
boot sales and surplus stores as it is quite surprising how often one sees them for sale in these circumstances, and purchasing them in this way can save a great deal of money. Taps, in particular, should be stored in such a way that they cannot rub against each other and, for this reason, should not be left loose in tins and drawers. A wooden block with holes to accept the shanks is the best way of storing them so that they will come to no harm.

14 SCREW CUTTING

Although threading with taps and dies has already been dealt with, and without doubt the majority of threads will probably be cut in this way, the art of screw cutting is well worth knowing. If taps and dies are used to generate threads, there is a limit on the size of thread that can be cut. The reason for this is quite simple: when screw cutting is carried out with a single point cutting tool, the only strain imposed on the lathe is the cutting edge of the tool. We can, in fact, take the tool along the work in easy stages and the whole process is light work.

When we use taps and dies we are trying to cut threads with cutting area over the whole circumference, be it an inside or outside thread. There is then a far greater area of contact between the cutting tool and the work, thus imposing greater strain. Of course, for very tiny threads, where screw cutting, particularly internal, is difficult because of the size of the thread. Taps and dies cannot be beaten. However, when we get to diameters over, say, ¼ inch or 6mm, the cutting area of taps and dies become larger with a larger area of contact. A tremendous effort is then needed to cut the thread. Even if, for these larger sizes, we wish to use a tap or die, then the work should first be cut on the lathe, and the taps and dies used as chasers.

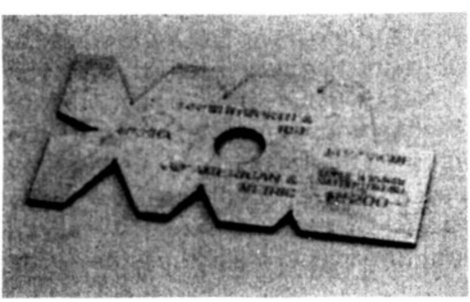
Let me explain exactly what is involved in screw cutting. I have mentioned elsewhere that, when we turn metal in the ordinary way, we do in fact cut a thread. This is so fine that it does not register as such but appears as a normal surface. Try an experiment. Turn down a surface using the hand wheel to drive the saddle. If you revolve the handle very slowly then you get a nice smooth surface. Next, wind the handle at about four times the speed without changing the speed of the lathe revolutions. The result will be a fine thread. As it is generated by hand it will not be very even, and also, because it is done by hand, you cannot go over it again and make it deeper. What you have to do, then, to get your thread is to make the lathe do the work for you.



A set of change wheels for a Cowell lathe as used to change the lead screw ratio for screw cutting.

Before we get down to using the lathe to make the thread, there are several things we need to know. For a start, we need to know the pitch of thread. The pitch is the number of threads over a given distance. If we are making imperial threads, we refer to the TPI which stands for threads per inch. Thus, if we have 20 TPI we will get twenty threads to the inch. Where metric threads are concerned we use the pitch measurement more directly. We might refer to a thread as having a pitch of 0.5mm or 1.25mm. This means that each complete circumference of the thread travels a distance of 0.5mm or 1.25mm. along its length.

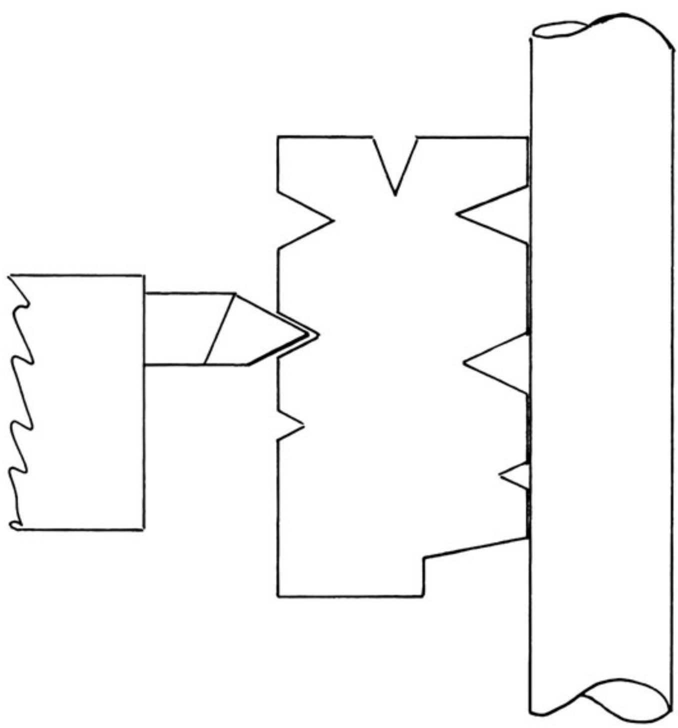
As well as the pitch, we need to know how deep the thread should be. After all, if we make the external thread one depth



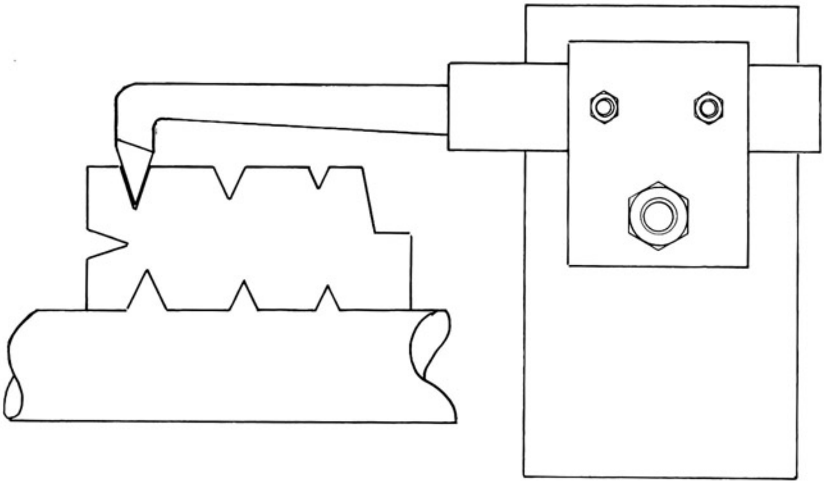
A screw cutting gauge can be used to check that tool angles are correct and to set tools up for screw cutting.

and the internal another, then the two will not fit. Put another way, if the depth is not correct and we wish to fit the component to a commercial item, it just will not go. If our home-cut thread is too deep, the fit will be sloppy, and if not deep enough far too tight. There is a formula for working out the depth of threads but it is far easier to refer to a chart, particularly as there are so many different threads which can be used, each with its own peculiarities.

We also need to know the angle of the thread. Metric threads, for example, have an angle of sixty degrees, British Association an angle of forty seven and a half degrees, and so on. Once again we can refer to a chart, and so there is no need to memorise all the angles. Not only are the threads at an angle but they also are either rounded or flattened at the top and bottom of the vee. This will also have some bearing on our threads. It may all sound somewhat complicated, but fortunately over the years all these things have been worked out for us and so it is just a case of reference.



This drawing shows how the screw cutting gauge rests on the work and the tool can be adjusted to get it square.



Setting up the gauge for inside screw cutting is more difficult. It can be set on the far side of the work but the cross slide has to be wound a long way across to set the tool.

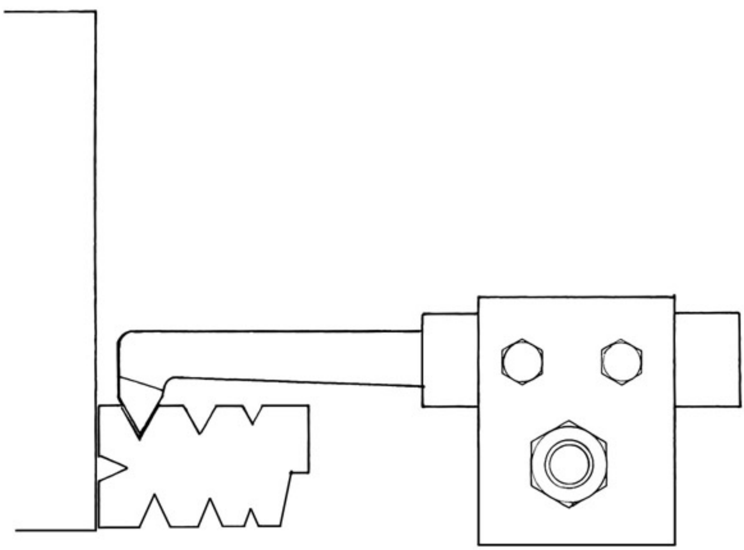
Let us start by thinking about the pitch of the thread. What we have to do is to get our lathe to operate in such a way that the tool will travel a certain distance at each revolution of the mandrel. If we are to produce a thread with a pitch of 1mm then, for each revolution of the lathe, the tool must travel 1mm. Each make of lathe will differ to some degree in the way this is achieved. The most common way is by setting a train of gears up. This gear train is already used for making the saddle operate under power and it is just a case of changing the ratio. Once more we will have charts to refer to, each manufacturer will supply a chart usually with the change wheels, which are bought as extra accessories and do not come as normal equipment.

Having set the lathe to operate at the correct pitch, we now need to get the correct angle. For this we have to grind the cutting tool to the required angle, or purchase one already suitably ground. The angle can be checked with reference to a thread gauge. This is a metal bar with a number of vees cut into it to correspond with different thread angles and possibly at various depths. It is simply a case of grinding a tool so that, if fitted into the required vee, no daylight will show at the sides. It still needs top and side rake as does any other turning tool.

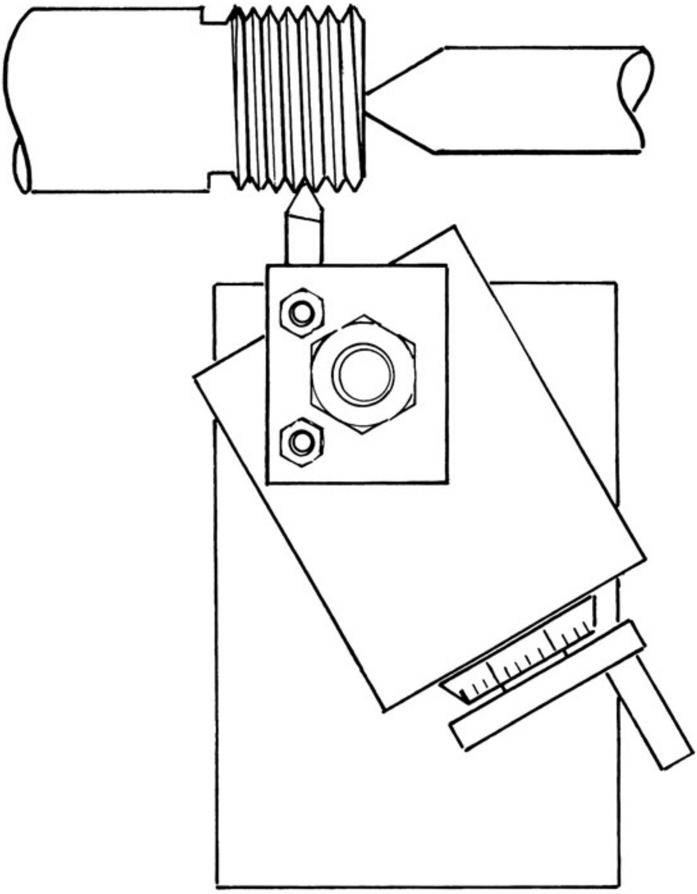
We also need to set the tool in such a way that it is at exactly

ninety degrees to the work. To do this, we can again use the guide laid flush along the work, wind the tool into it and adjust it until it is square. For internal threads it is a little different as, even if the hole is large enought to get the tool and the gauge in, we cannot see it. If the outside diameter of the work is parallel to the internal thread, then the gauge can be laid on the far side of the work and used in that way. There are some problems doing this, the main one being that the cross slide has to go rather far across to line up the tool. Another way, and one that also applies to work where the outside diameter is not parallel to the internal thread, is to place the gauge against the faceplate and then put the tool in the required place. It is not necessary to put the gauge in the centre of the faceplate – as long as it is square, that is all that matters, and this can be done using the outer circumference.

The thread depth can easily be worked out by using the graduations on the cross slide dial, care being taken on the first cut to get the reading at the exact point where the tool starts to pick up the work. Having cut the thread to a partial depth, it will be necessary to withdraw the tool and start again at the beginning. On larger lathes, special indicators are used for this. It is not possible with compact lathes and the usual thing is to withdraw the tool with the saddle still in gear. Reverse the



If the gauge is put against the faceplate, the inside screw cutting tool can be adjusted much more easily.



The top slide can be set to half the thread angle and this means that the tool only cuts on one edge and so imposes less strain on the lathe.

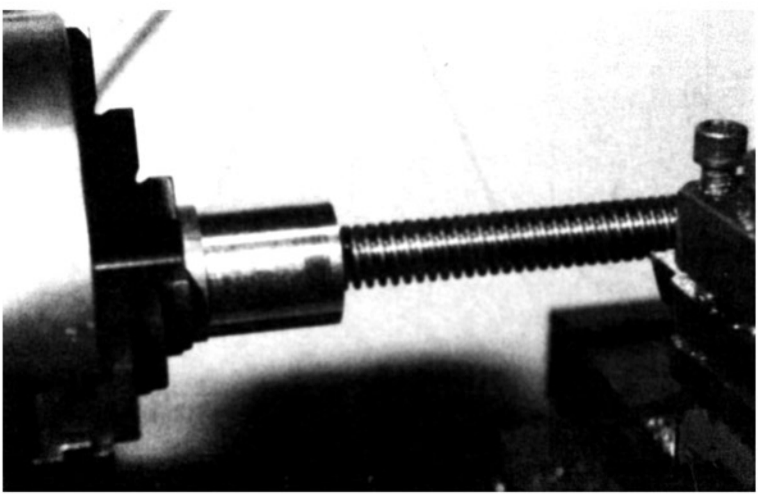
lathe and take the tool back beyond the start of the thread. The lathe can be put in a forward position again and the cut repeated at a greater depth. This procedure can be repeated until the full depth is reached.

Unless for some reason it is impossible, the end of a thread should always be undercut. While this sounds complicated, all that it means is that a groove is cut at the end where the tool will stop, the tool then runs into this groove and this gives an indication that it is time to stop the lathe. If there is no undercut, there is always the danger of over-running and this can be particularly awkward as the tool gets to its full depth. It means that there is every chance it will dig into the metal and break, or

possibly cause the work to slip in the chuck and so move out of position. Incidentally, all screw cutting should be carried out at very low speed, irrespective of the correct cutting speed of the metal.

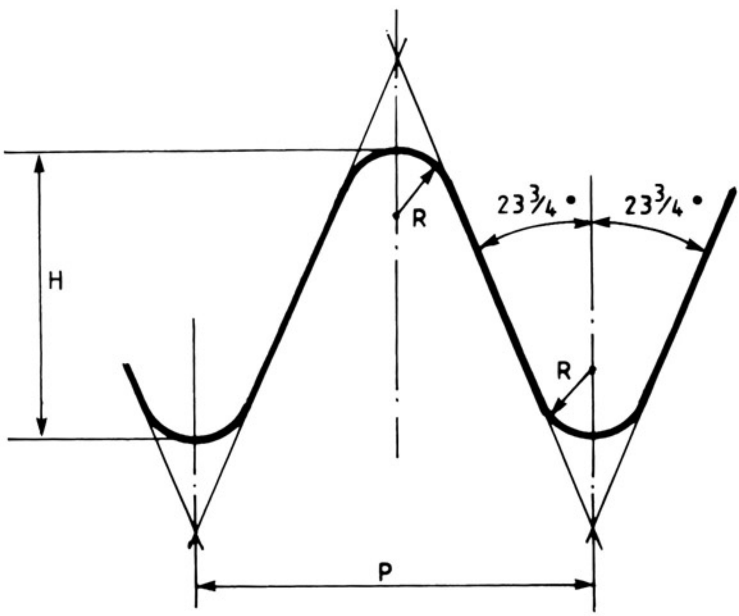
Although in theory we now have the ideal situation for screw cutting, and certainly it will work as described, it is possible to improve on the operation. As I have described, the cross slide or top slide will be wound in by a set amount for each cut. This means that our vee-pointed tool digs further into the vee at each movement. This is a far from ideal situation as the tool has to cut on both sides of the vee, and a lot of strain is imposed on the lathe with this doubled cutting surface. If we set our top slide over to half the thread angle, but keep the tool post and tool square, then as we advance the tool it will go at an angle and so only cut with the leading edge, thus reducing the forces involved. The effect of doing this will be noticed immediately and the result is a cleaner thread. Frequently, when a thread is cut with both edges, the finished result is very ragged and needs cleaning before it can be used; cutting on one edge stops this. However, we do need to double the movement of the top slide to get the required depth, as it is now only travelling half the distance for each turn of the handle.

Setting the top slide to such an angle for internal threads may be a little more awkward, as frequently room is at a premium. However, if at all possible, the thread should be cut in this fashion.



Cutting a lead screw for a small vice.

A gear train set up on a Cowell lathe.



The drawing shows how a thread is formed of an angle and rounded at top and bottom. The angle and depth of thread must be known in order to machine the thread.

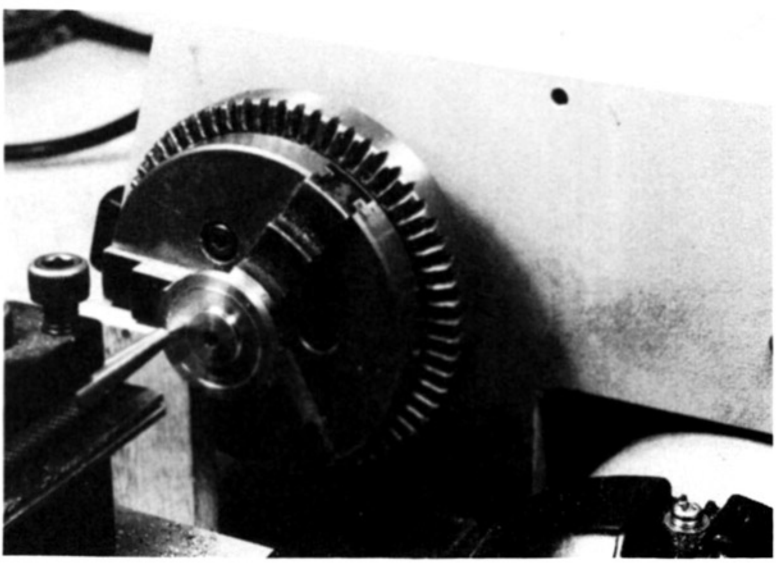
When threads are used for driving purposes, such as in the case of a lead screw, then they are usually either square-shaped or in a form called acme, which has a sloping side of fourteen and a half degrees but is flat at the top and bottom. Cutting these threads is done in the same way as when cutting vee threads but, because of their shape, it is not possible to set the topslide over and the tool must go in to cut on both edges. Getting male and female to match can be a problem, it is as well to make up a tap while set up for the external thread. This is not difficult, and simply involves cutting the thread on silver steel and then making a couple of flutes along it to give swarf clearance. The tap is not used for cutting the internal thread but merely for cleaning it out and sizing it. The tap should be hardened and tempered to a light straw colour before use.

Many model engineers are frightened of screw cutting, but there is no need to be. Once it has been done a couple of times it becomes very easy, and many would rather cut threads than use taps and dies.

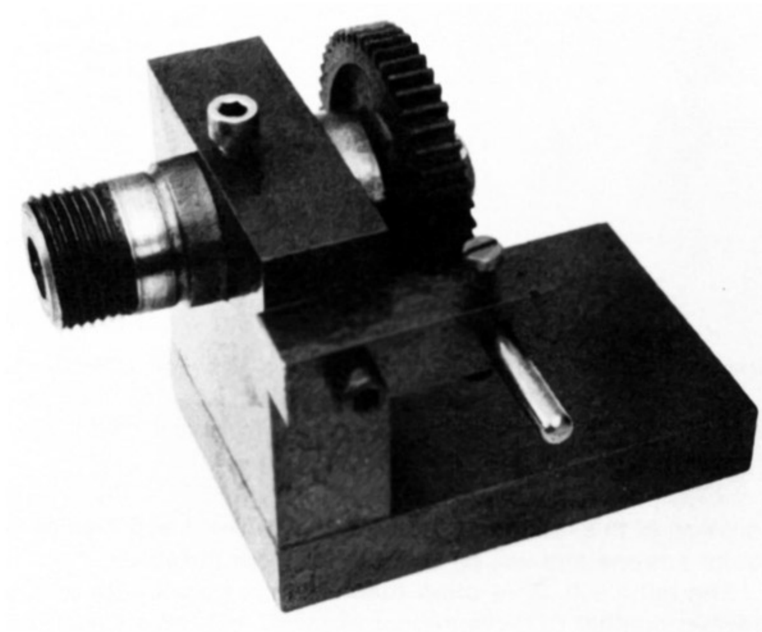
15 GRADUATING AND DIVIDING

One of the most difficult tasks facing the operator of the compact lathe is dividing accurately. Fortunately, unless we are clockmakers, it is an operation that will only be occasionally used. Chapter 20 deals with some of the needs of the clockmaker. But let us ask ourselves when and why will we need to divide?

Graduating work is one reason, and by that I mean when we need to mark components into sections, as are the handwheels of the lathe and milling attachment. We may need, from time to time, to make a round bar square, or may even need to make a



A wooden block placed under the jaw of the three-jaw chuck will allow three divisions. We also see in this photograph a centre punch mounted in the tool post. This is wound in and marks the component for drilling. The line is scribed so that if there are any discrepancies in the positioning of the centre punch they will show up.

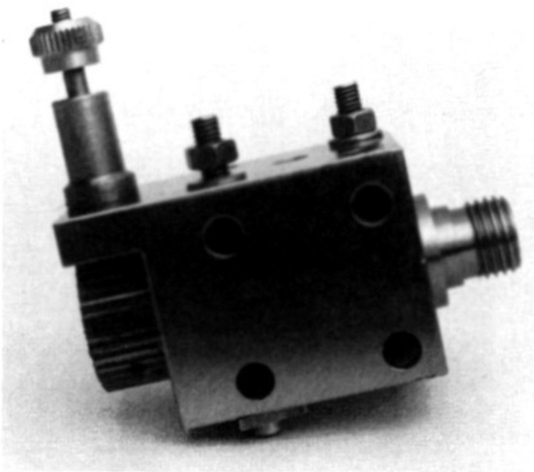


A simple home-made dividing head using a lathe change wheel and a plunger. The short mandrel is screwed to take the lathe chuck.

gear wheel. We are also going to need to divide work when milling.

The simplest divisions we can get are three and four. All that is needed for these is to put the work in a three or four-jaw chuck and put a piece of wood or metal under one jaw of the chuck. The work can then be filed or machined and, when completed, turned round with the same object under the next jaw, and so on. In this way we use the accuracy of the chuck for our divisions. Using this method it is also possible to mark out six divisions. Use the three-jaw chuck and make a mark with a scriber held in the lathe tool post. If the mark is taken right across the work, and similar marks made using the other two jaws, then we have our six divisions. It is not possible to use the jaws directly to work on a component divided into six, but even being able to mark the divisions is a help.

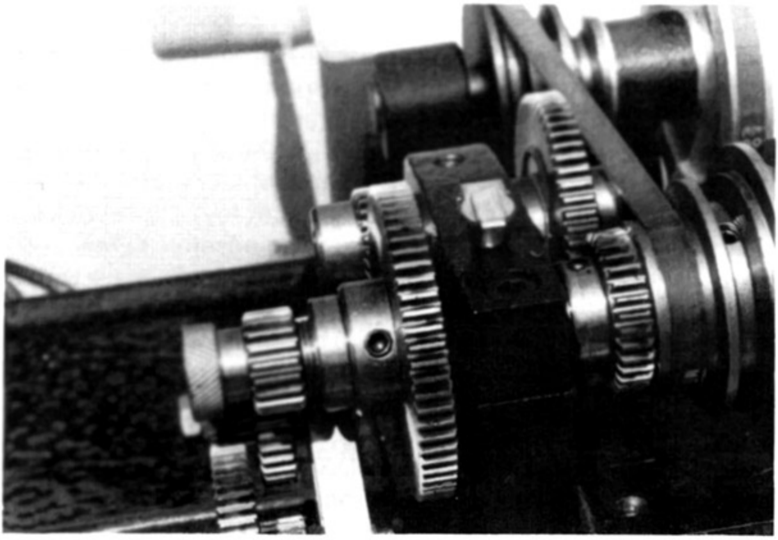
Some lathes have facilities for fitting division plates. These are usually a plate with a series of holes, and a plunger fits into the hole. The plate being captive with the mandrel allows the work to be rotated and located at any point in the division plate. If we then have sixty divisions, we are able to get any direct



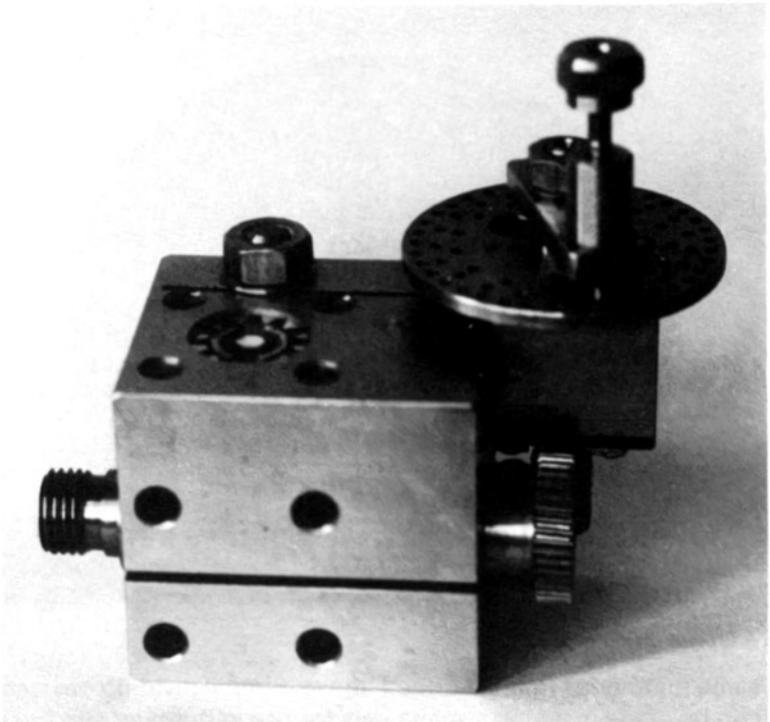
A similar device to the home-made one but this time a commercial version by Cowell.

division of this number, 60–30–20–15–10–5–4–3 and 2 which is quite a range and will be suitable for most purposes.

The lathe will more often than not only be used for a very limited number of divisions: for example, putting a square on the end of a round bar. The material can be located in the correct position and the flat section filed or milled if a milling attachment with separate motor is available. If the component



The large change wheel on this Cowell lathe could be used for dividing if some sort of plunger can be fitted up to engage with the teeth.

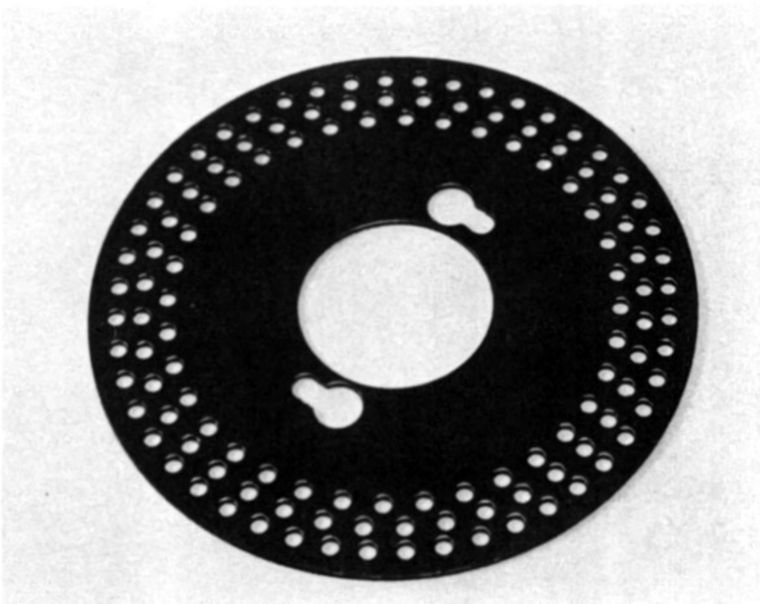


The Cowell dividing head uses a worm and a dividing plate to give a large number of divisions.

is to be filed, a filing rest should be used. This consists of two rollers on a stand that are height adjustable. The file is kept flat by running it along the rollers. Such a device may be available for the lathe in question but, if not, is very simple to make.

Another situation where divisions may be required for work mounted in a lathe is if a number of holes have to be drilled evenly round the part being made. A typical example here is with a cylinder cover. In this case, a line is first scribed round the work at the correct distance from the edge and a centre punch mounted in the tool post. The saddle can be wound in and the centre punch will mark the component at the point where the hole is to be drilled. This can be done at any number of spaces for which a division is available.

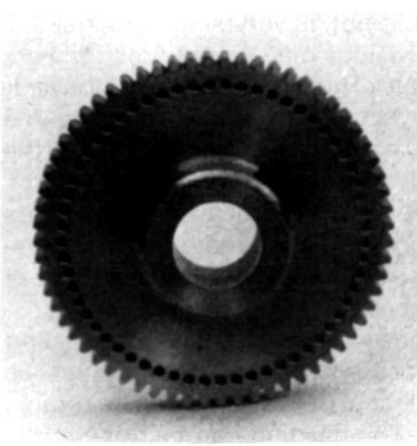
It is most likely that divisions will be required during milling operations. Round work for this purpose must then be mounted in a chuck or on a faceplate so that it can be rotated and also locked in position. The dividing can be done in the



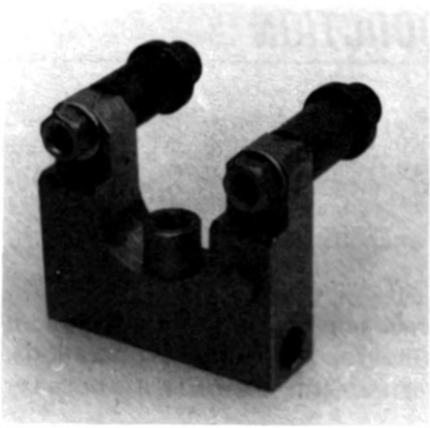
A typical dividing plate.

same manner as that described above. Simple dividing devices can be made up using gear wheels for use in this way and they are very effective. Such instruments can also be obtained as accessories for compact lathes.

Those requiring more sophisticated means of division will need a proper dividing head. This consists of a worm drive which operates a spindle to which is held the work. The drive is connected to a division plate, usually with three or more



A change wheel that also has a series of holes drilled round the circumference to accept a plunger.



The Cowell filing rest, a typical component likely to be used when dividing.

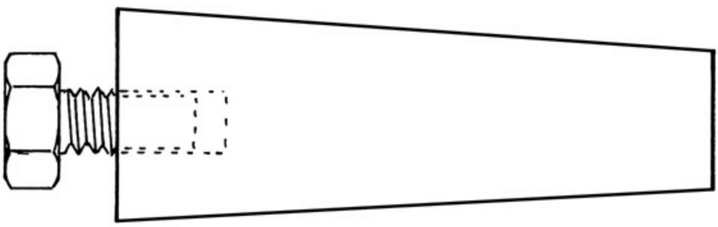
differing rows of holes round it. The plate will give a number of divisions and the worm which is attached to a graduated wheel can be used to sub-divide these. An almost infinite number is then available.

I suggest that, unless involved in clockmaking, you start with simple dividing methods and make yourself something that will give you the numbers you require. If a gear wheel cannot be used, and a small division plate cannot be obtained, then marking out and drilling your own will be necessary. This will need to be done very carefully as a mistake will mean that all work done with it will be wrong. To get the number of required divisions the chord of a circle must be used and a chart giving the figures is provided for your benefit (see Appendix 1).

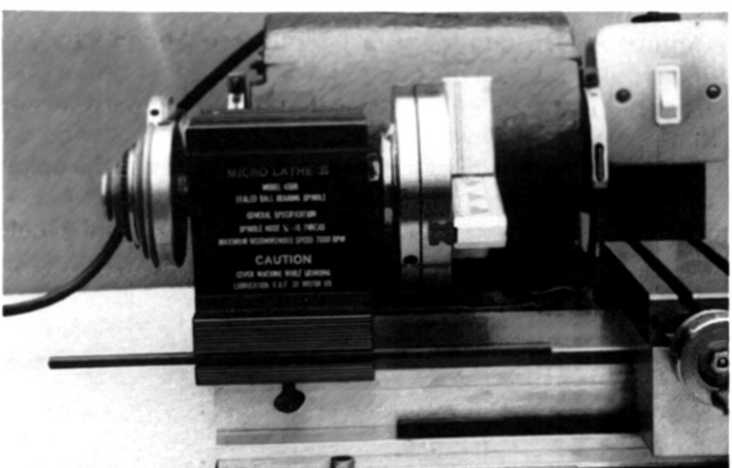
Small tools for batch production work can either be grouped up from high speed steel or fabricated from high carbon steel such as silver steel, in which case they must be hardened and tempered. To harden, heat the steel until it becomes the colour of a boiled carrot and immediately quench it in oil or water. To temper after hardening, clean the steel until it is bright. Heat it and watch the colour change. When it is the colour of straw, quench it again.

16 BATCH PRODUCTION

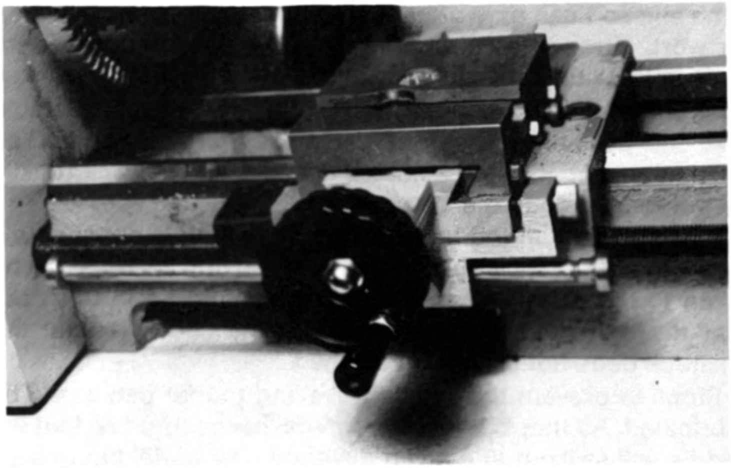
From time to time, more than one of the same component needs to be made and this will involve repetition of operations. No matter how carefully measurements are made, it is not easy



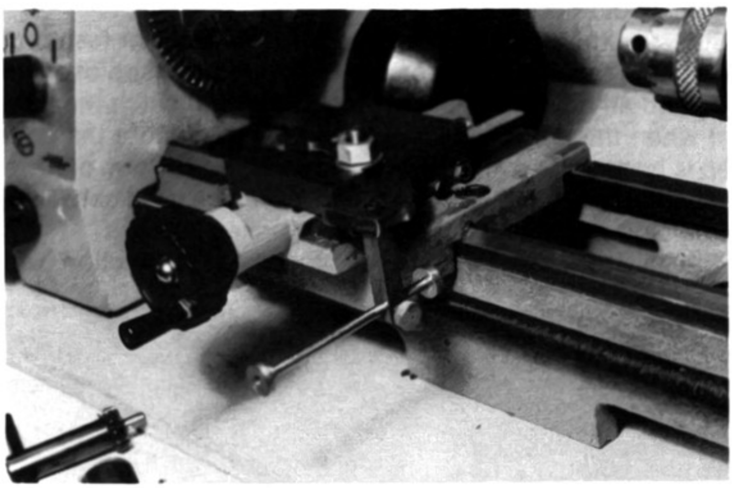
Drawing showing how a screw can be fitted to a taper. This can be inserted behind the chuck and enables the operator to know exactly how far the work is loaded.



Fitted immediately underneath the headstock of the Peatol lathe is an adjustable bar that acts as a saddle stop.



A home-made saddle stop for a Toyo 210 lathe. The stop is an adjustable bar which strikes the headstock casing fitted to a bracket which screws on the saddle of the lathe.



A cross slide stop made for a Toyo 210 lathe and consisting of an adjustable bar fitting in a holder secured in the cross slide tee slot. The end of the bar simply strikes on the lathe bed.

to get two or more identical components to the tolerances that are likely to be required. The use of the lathe graduations certainly helps but it is very time-consuming trying constantly to run the tool to the same measurement. The answer to this sort of thing is to make up simple stops or guides.

How such equipment should be made will vary from lathe to

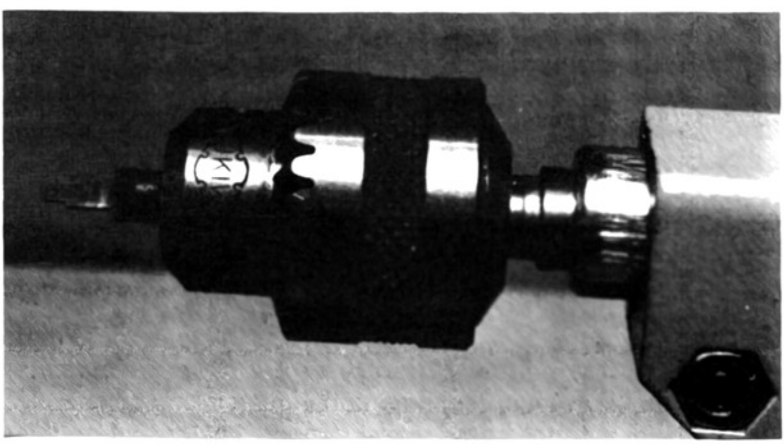
lathe and so I can only offer suggestions. For example, a stop for work, fitted in a chuck or collet so that each component goes in to exactly the same distance, can be made by using a taper that will fit the mandrel, and fitting this with an adjustable bolt and possibly a lock nut. Once the first component has been fitted, and the stop adjusted to suit it, all others can easily be put in at exactly the same depth.

If using a drill in the tailstock chuck, a simple collar with a screw to tighten it can be slipped over the drill and this can be taken to the depth required. Care must be taken in this case that the drill does not move back in the chuck or that the tailstock does not slip along the bed.

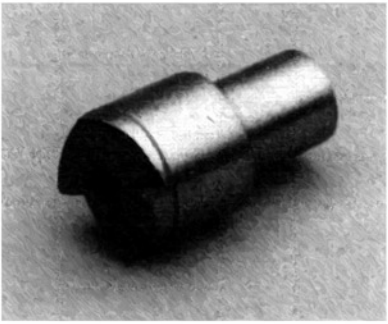
Stops to prevent the saddle travelling too far can easily be fabricated. All that is needed is a metal bar secured so that the saddle will strike it at a given distance. The metal bar or stop can be secured in some way near the headstock. If it is not possible to fit it to the lathe, then it could be fitted to the bench, or even an ordinary screw in the bench which stopped the saddle would do the trick.

Stops on the cross slide can be made in a similar fashion. I have found that usually these can be located in a tee slot on the slide and an adjustable bar arranged that will catch the lathe bed when the cross slide is wound in. Where more than one stop is needed for a given movement, then some form of turret can be used; failing this, metal spacers can be used between a single stop and the point at which it strikes home.

The tailstock can also be employed in connection with



A home-made stepped drill. One operation drills two different diameter holes and also counterbores.



Known as a rose bit, this little tool can be mounted in the tailstock chuck and is a quick means of reducing metal. It is a piece of silver steel with a hole in it and four cutting edges on the outside. The steel is hardened and tempered.

simple batch production work. Again, a simple stop consisting of a morse taper with a bolt can be used, or a plain metal bar in the tailstock chuck. A great deal will depend on what other purposes the tailstock is being used for at the time. It is also possible to make up simple cutting tools that can be used from the tailstock to give an extra dimension in this way.

Form tools or tools made to the exact shape of the component under construction are very useful, as one operation can, with their use, replace several. Small stepped drills can be easily made to fit in the tailstock chuck as well and these can save a great deal of time, as well as a lot of tool changing.

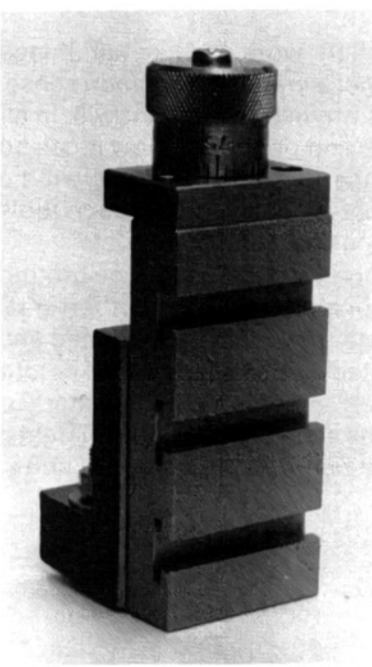
Really simple batch production work is, like all things connected with the compact lathe, a matter of common sense. If several identical components are needed, then it will, in all probability, pay to sit for a while and ponder on how it can be done. The time taken to produce the stops or tools will be repaid in the added accuracy that is achieved, and such tools are always worth keeping for possible future products.

Small tools for batch production work can either be ground up from high speed steel or fabricated from high carbon steel such as silver steel, in which case they must be hardened and tempered. To harden, heat the steel until it becomes the colour of a boiled carrot and immediately quench it in oil or water. To temper after hardening, clean the steel until it is bright. Heat it and watch the colour change. When it is the colour of straw, quench it again.

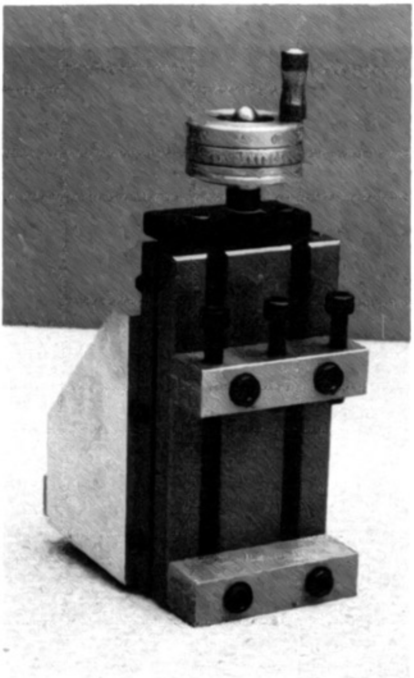
17 MILLING

Modern vertical milling attachments have made milling considerably easier on the compact lathe than it was previously, particularly if we think back to the very early days before the introduction of the vertical slide. However, the vertical slide still has its part to play, and indeed many milling operations can be carried out without any additional equipment other than some form of milling cutter.

For the newcomer to the hobby and to the use of such a machine, let me first of all explain what is meant by milling. It is really the exact opposite to turning operations. When turning, the work revolves and the tool or cutter remains rigid, although



A vertical slide by Cowells. This simple accessory allows vertical movement of work and, as it is mounted on the cross slide, there are also two horizontal movements. The result is all the movement we can expect from a vertical milling machine. Of necessity the vertical slide cannot be as rigid as a milling machine and so all work must be done in easier stages.

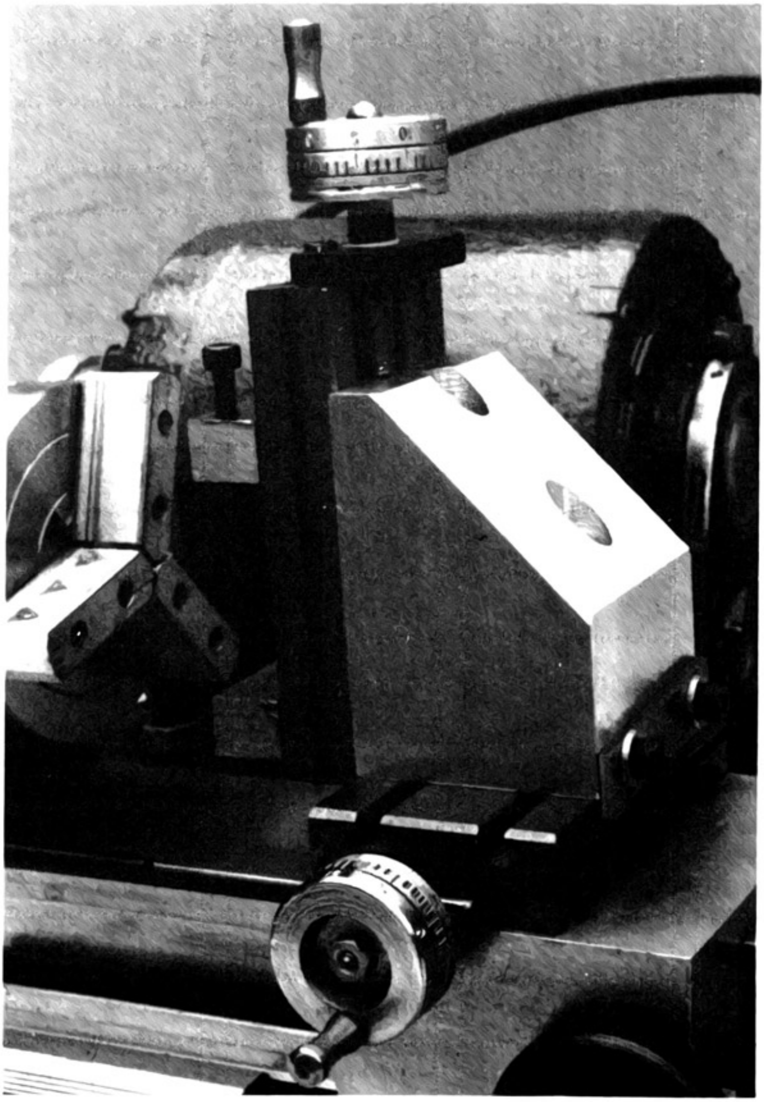


A vertical slide from Peatol. This differs considerably from most slides as it also has a built-in vice or clamp to hold work. it is of particularly robust construction, the heavy casting at the rear given extra support.

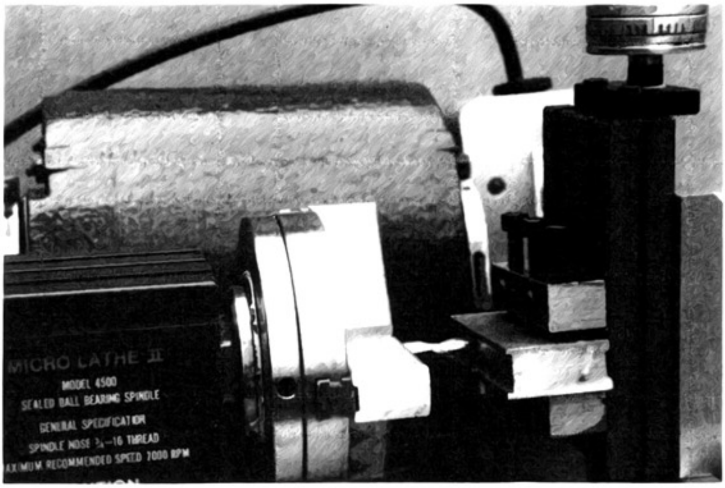
able to traverse the work either lengthwise or across the face. When we are milling, the work is held captive but is traversed along or across the machine while the cutter rotates in the lathe mandrel, or in the vertical milling attachment.

Let us look at it this way. If we put a milling cutter in the lathe chuck and bolt our work on the cross slide, then bring the work to touch the rotating cutter, this will start to cut the metal. If we move the cross slide, then the cutter will machine the work flat at the area of contact. If the cutter is of sufficient size to cover the whole of the work, then the whole area will be flattened. If it is of a smaller diameter, it will cut a groove. As when turning, the cutter must not be dug in too deeply and so several passing cuts will need to be made to complete the machining.

It is obvious from the above paragraph that the only area to be machined will be that which is in line with the nose of the lathe, as the work cannot be moved up and down in order to cover a larger area. Careful resetting with suitable packing may well allow this to be done and, for those with no other facilities, there is no reason why this method should not be resorted to. However, it will be virtually impossible to remove all marks (known as witness marks) by machining but the method is still



A second view of the Peatol vertical slide, showing the heavy rear casting. A plate at the back of the casting butts up to the cross slide and ensures that the slide is mounted square to the mandrel of the lathe. Getting a vertical slide square is always a problem. Where a slide does not have a facility built into it, butt the working face of it to the lathe faceplate to ensure squareness. If necessary a spacer can be put between the table of the slide and the faceplate while adjustments are made.



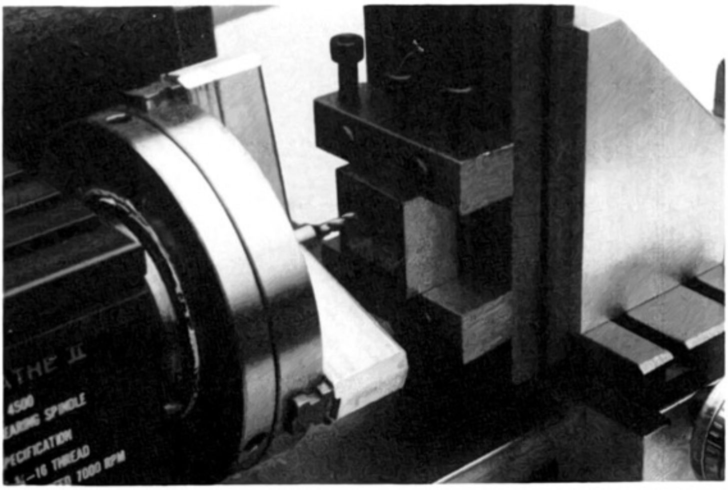
Milling a slot in a locomotive axlebox mounted on a vertical slide.

useful, as a file can be used for finishing. Without the use of a milling cutter, the whole lot would have had to be filed, which is a somewhat energetic way of spending your free time.

We can use a vertical slide to get the extra movement which means the work does not have to be unbolted for each cut. This little device bolts to the cross slide, and when the work is secured to it, will lift or lower it as required. The result is that we now have three movements which will allow all the work to be machined at the one setting.

Work can be held on the vertical slide, either in a machine vice or by direct bolting. It largely depends on the size and shape of the work. If it is bolted direct to the slide, make sure that there are sufficient bolts to ensure that the work does not break free and either turn round or actually come off. Considerable force is generated when milling and, if the work is spoilt at the last operation, in all probability it will mean starting again.

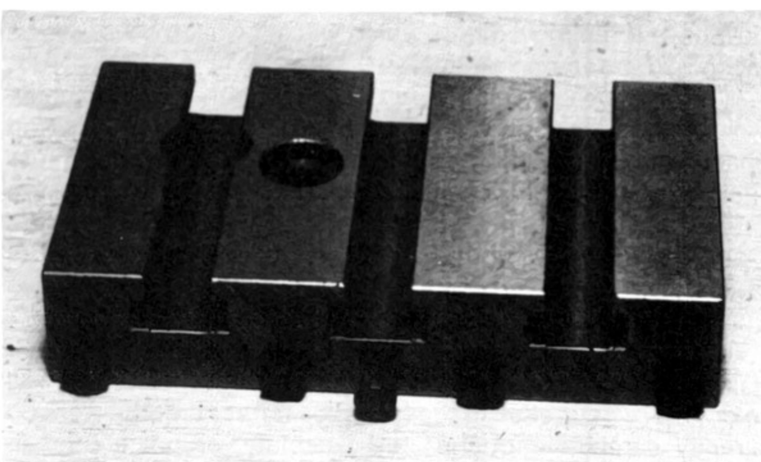
In order to ensure that the work is accurate, it is essential that it is mounted at exactly ninety degrees to the cutter. It is as well to do this by reference to the faceplate. Either butt the work up directly so that it touches the faceplate, or put a ruler in between and use that as a guide. It will probably need to be set exactly horizontal. Here we can either use a clock or indicator, or a scribing block. If the latter is used, put a piece of white paper behind so that any slight discrepancy will show up. It is also essential that similar treatment is given to a machine vice if



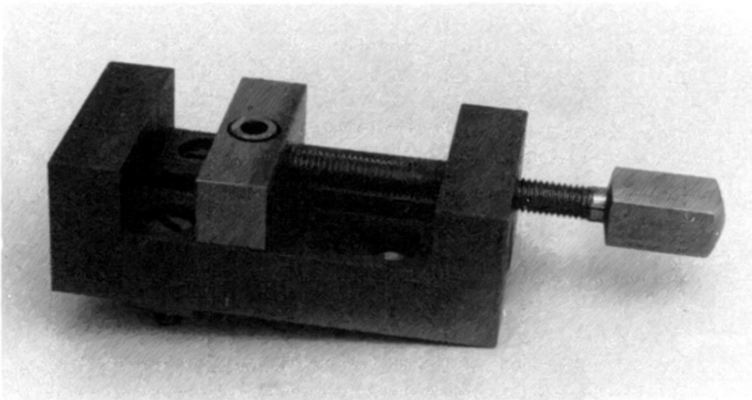
The recess in a slide valve being machined on a vertical slide.

one is to be used; again, if this is not done there will be a lack of accuracy.

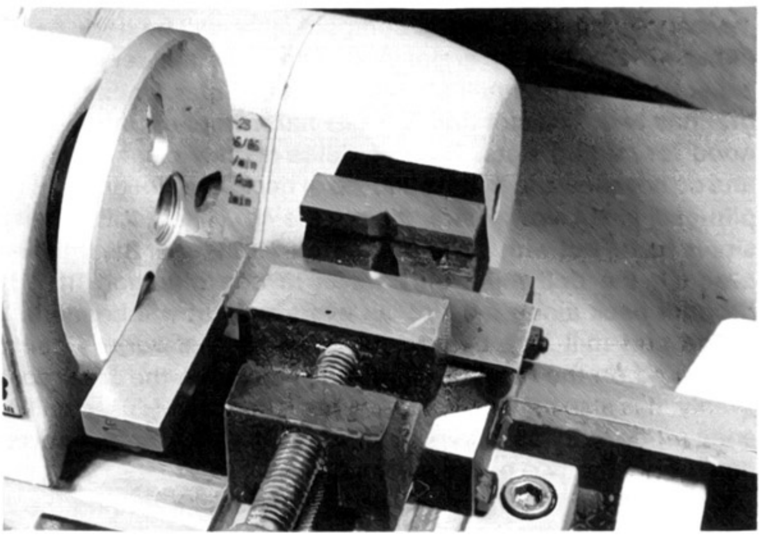
If a vertical milling attachment is in use, it will be necessary to set the work square on the table. These devices use the cross slide as a milling table but, in some cases, an extra large plate is available to allow larger work than could normally be managed



Vertical drill/mill attachments add another dimension to a lathe. The only difficulty can be that the cross slide which acts as a milling table is often rather on the small side for mounting work. This photograph shows a milling table for a Toyo 210 lathe which can take the place of the cross slide and give a great deal of extra space.

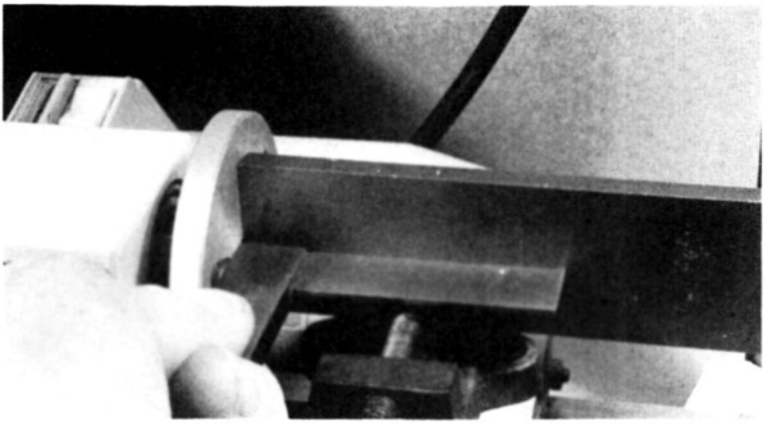


If a mill/drill attachment is to be used, a machine vice such as this can be used to hold work.



The machine vice must be mounted exactly square to the milling table to ensure accuracy. There are several ways of so doing. Here we see a square laid against the vice jaw and butted to the faceplate.

to be bolted down on the ordinary cross slide. The attachment raises and lowers the cutter to the work, which is the opposite of the vertical slide where the work is raised and lowered to the cutter. However, basically the principle is the same and the other two movements are obtained by winding the cross slide handle in exactly the same way as was done with the vertical slide.



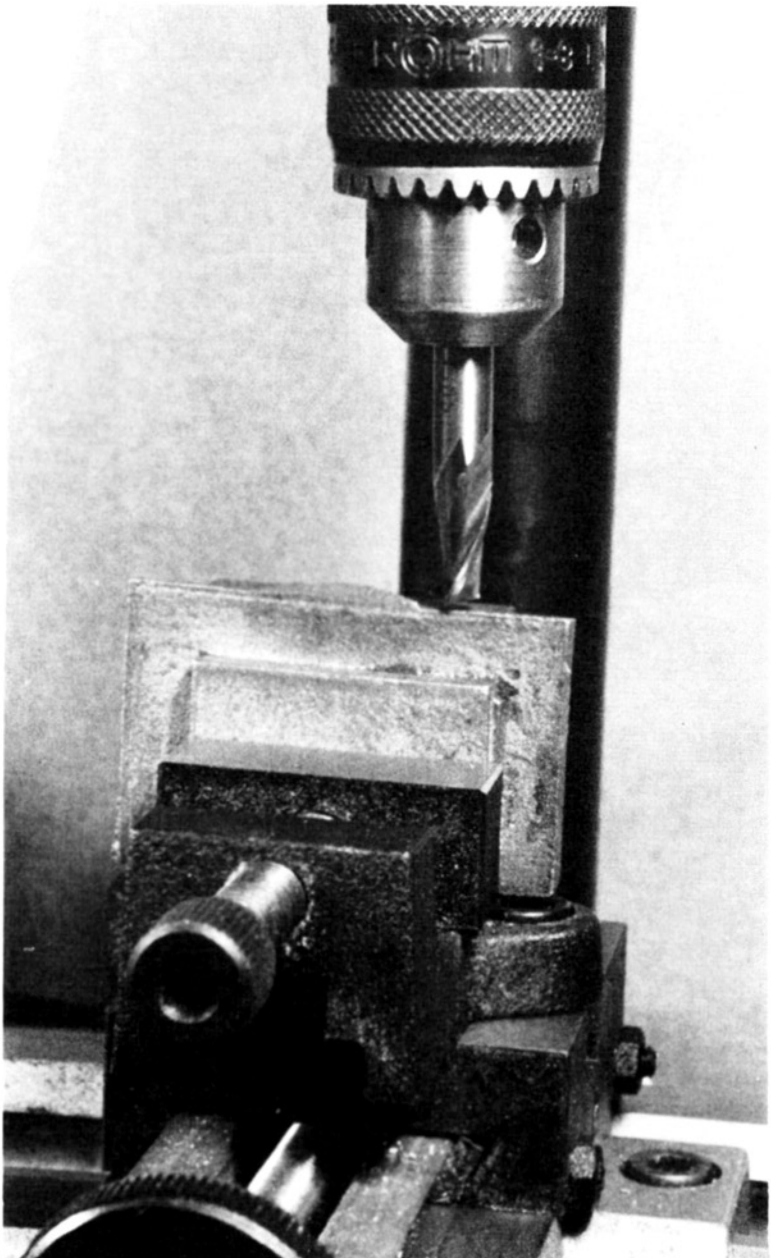
An alternative to putting the square against the vice jaw is to put a bar of metal in the vice and lay the square against that.

Most milling work on the compact lathe will be done using either an end mill or a slot drill. The tools are very similar, except that the end mill usually has four flutes while the slot drill has two. The slot drill is, as its name implies, particularly good for cutting slots. The two flutes quickly clear the swarf and do not allow too much build-up of heat. The slot drill can be plunged, albeit slowly, straight into the work like a drill. When a slot is being cut with a slot drill of the diameter of the finished product, the drill must only travel in one direction. If it is brought back along the slot, an oversized cut will be made.

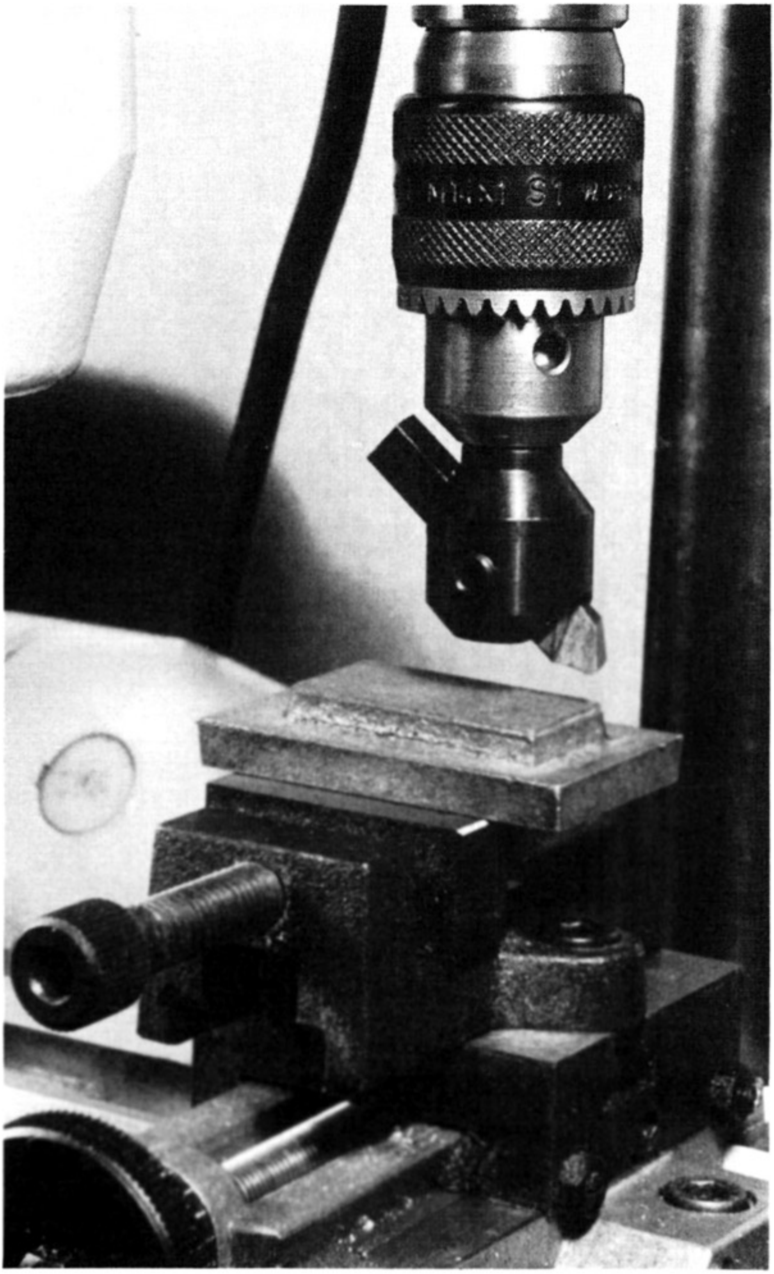
The end mill is a better tool to use if the work is being machined on the face, the four flutes covering the area more evenly. It is also better when the side of the cutter is used on the edge of the work as, again, the four flutes give a far more even finish than the two of the slot drill.

It is possible to obtain end mills with three flutes and these are a good compromise between the slot drill and end mill. Occasionally, particularly if surplus equipment is purchased, milling cutters with six or even eight flutes may be found. These should be used in the same way as four flute cutters.

The use of milling cutters of the type used on horizontal milling machines is not recommended. However, slitting saws have their places in the model engineer's workshop. These are very tiny, circular saws and can be obtained at very reasonable prices. They must be mounted on an arbor for use. They are quick and cut very accurately. They are particularly useful for cutting tiny keyways or where work needs to be sawn into two or more parts. All cutters must be held firmly when in use.



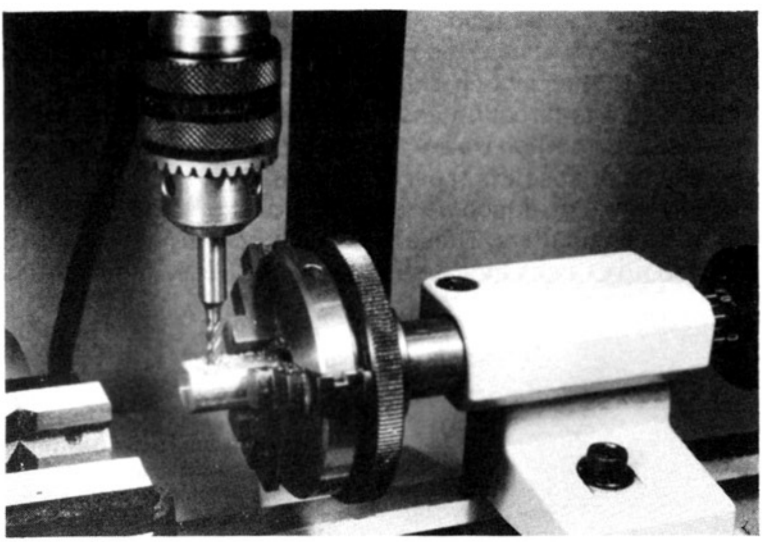
The steam chest cover for a 'Minnie' traction engine being machined on a mill/drill attachment.



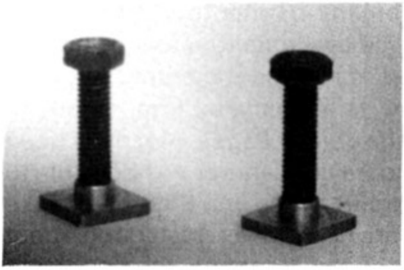
Large areas that need to be flat can be dealt with by using a fly cutter. This single point tool (this is the Unimat model) is rotated at a very slow speed and can give an exceptionally good finish.

End mills need special equipment in order to sharpen them. Such equipment is unlikely to be available to many owners of compact lathes. The alternative is to keep the blunt tools until there are a few, and take them to a specialist firm, details of which can usually be found in the *Yellow Pages*. Slot drills need similar equipment if they are to be kept sharp. It is possible to prolong the life of these cutters in two ways. First of all, take care of them and ensure they are not allowed just to roll about together in a tin or drawer. When this happens, the edges rub together and quickly become blunted. If they must be kept in such circumstances, then wrap insulating tape round the cutting edges to protect them. It is easily peeled off when they are needed and the small cost involved is soon repaid in the saving on wear and tear.

The alternative, and one I always use, is to drill holes in a wooden block and keep them in this. Not only do the edges remain sharp but it is also easy to see the size of cutter which is needed. The second way to extend the working life of a cutter is just to keep the cutting edges sharp with a small slip stone, or the modern alternative, a diamond lap. The slot drill can have the cutting edges ground on an ordinary grindstone if it



Round work can be a problem to hold when it is necessary to mill flats on it. With a mill drill attachment it can be held in the lathe chuck, but the lathe mandrel must be locked to prevent movement while machining is carried out. Here we see the Unimat chuck mounted on the tailstock, which has a thread to accept it. This style of mounting guarantees the work will not move.

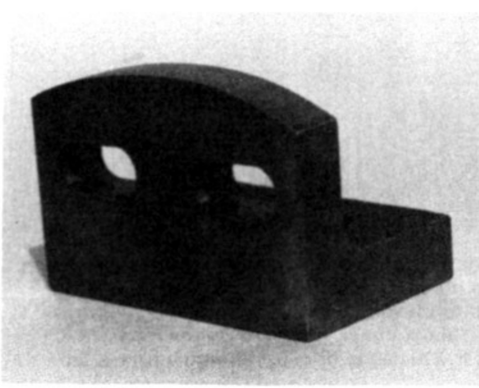


Work for clamping to the milling table should always be held with tee bolts such as these, in order to prevent strain on the tee slots.

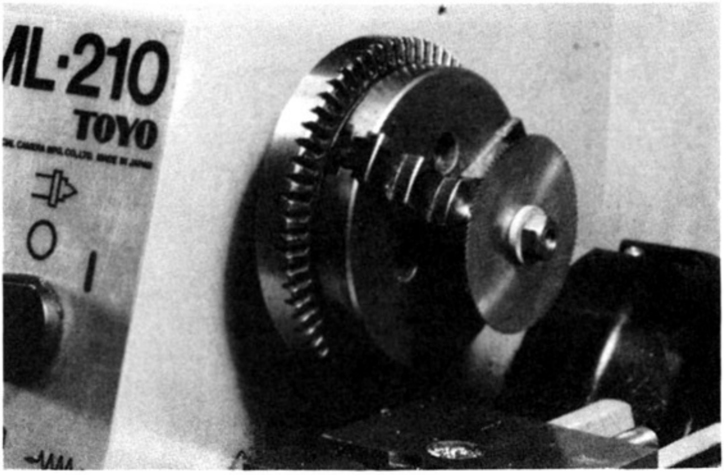
becomes very badly worn. Care must be taken to keep the correct cutting angle. This should not be attempted with an end mill. With a slot drill, if the two edges happen to be ground unevenly, and it is very hard to do otherwise without proper equipment, then it will still cut on one edge. Under no circumstances should the cutting edges on the sides of cutters, whether end mills or slot drills, be sharpened with a grindstone, but they can be touched up as suggested above.

Cutters must be held securely when in use. If they are mounted in the lathe and the work on the cross slide, whether with a vertical slide or not, then they can be held in either a collet or a three-jaw chuck. Holding them in a drill chuck inserted in the lathe is not advisable, as these are secured only with a small morse taper and are liable to pull away under pressure. We must here recognise the different forces involved in milling to those when drilling. When we drill metal, all the thrust is in one direction and this drives a morse taper firmly into the socket. When we are milling, the thrust is also sideways and this can cause the taper to release.

Where a milling attachment is used, collets should be used to secure milling cutters. These are usually held in position with a screwed nose cap. Once again it must be stressed that cutters



An angle plate such as this little one from Cowells is useful for clamping work on edge to a milling table. Like the machine vice, it should be mounted square to the milling table, unless the component being machined calls for a particular angle.



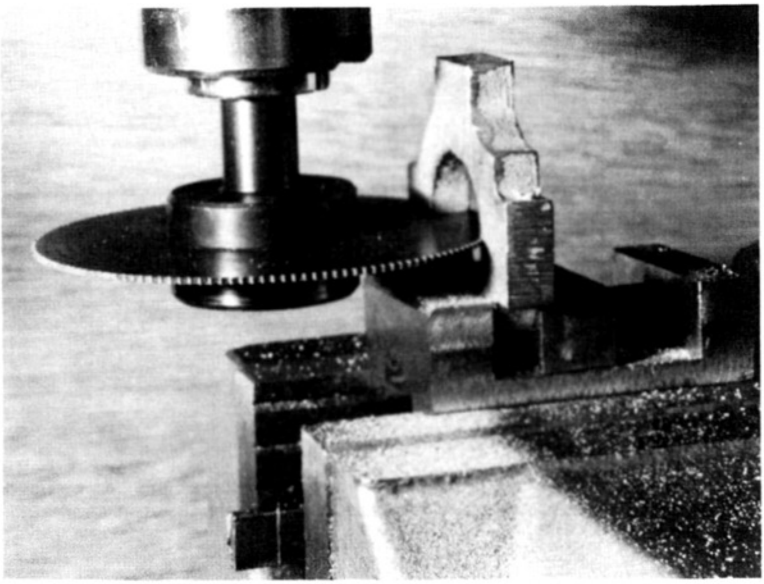
Where very thin slots are required a slitting saw such as this can be used. It can either be mounted as in this case in a lathe chuck, or in a mill drill attachment.

should not be held in a drill chuck that is held in with a taper. Other fixings for drill chucks may be suitable, however. Care must be taken that the shanks of cutters fit the collets properly. Cutters and collets come in metric and imperial sizes and, while these are very similar, they are not quite the same. The difference is sufficient for a cutter not to be secured properly if a metric one is mounted in an imperial collet. Many milling cutters have threaded ends. This is to allow them to be used in special collet chucks. I know of no compact lathe attachment using this type of collet. However, these types of cutters will hold in ordinary split collets drawn up tightly. Some cutters do not have the threads and these too will hold securely in split collets.

It is essential when milling that a suitable cutting speed for the cutter size, and the material being machined, is used. It will not be possible to use the correct speed all the time, as the number of speeds available is, of necessity, somewhat limited. The selected speed should be slightly slower than the correct one which can either be calculated or obtained from a chart.

Cutting liquids should also be used where appropriate. A combination of the correct speed and cutting lubricant achieves a good finish.

It is easy to become impatient when milling, and either feed the cutter too fast or cut too deeply into the work. Both faults can lead to disaster – not only bad work, but also the possibility



This photograph was not taken on a compact lathe but shows a slitting saw in use.

of broken cutters. The depth and feed should be such that there is no undue vibration when operations are being carried out. A little experience will allow the operator to feel when all is well as far as depth is concerned, and the cutter will more or less feed itself if allowed to do so by gentle handling of the machine controls.

Work that is to be milled can first be marked out and the milling operations carried out to this marking. It is, however, a little difficult to see when a rotating cutter is exactly parallel to a line. It is far better, therefore, if the graduations on the handles of the machine can be used instead of marking out. An edge finder can be used to establish where the cutter is in relation to the work, and the distance travelled from there worked out by counting the revolutions and parts of revolution of the handles. Depth of cut can be established by sticking a piece of tissue paper to the work: normally an engineer uses a cigarette paper. The paper must lie flush with the work. Bring the cutter to the job, or the job to the cutter, until the piece of paper just catches on the cutter, which at this stage must be near enough in contact with the work, and again the machine's graduations can be used to get the correct depth of cut. Working in this way, we use the built-in accuracy of the machine to ensure our own accuracy.

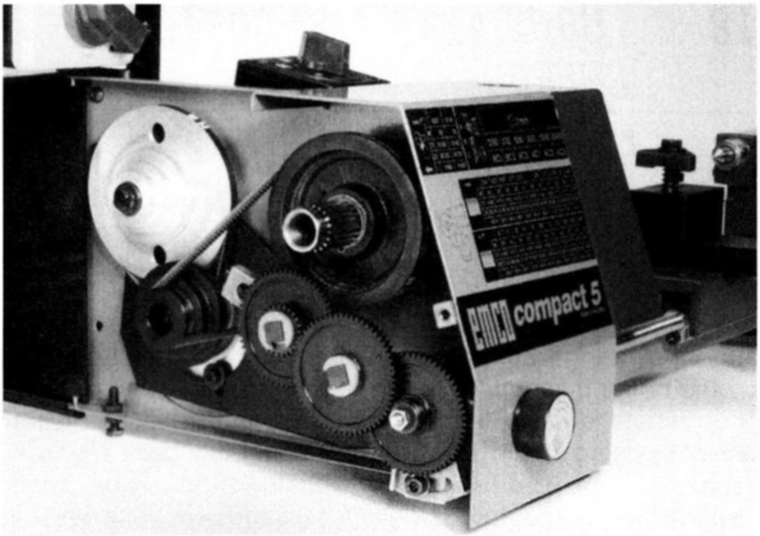
18 LUBRICANTS AND CUTTING SPEEDS

The subject of cutting speed and lubricant is highly important, although strangely enough it is sometimes completely ignored by the home machinist. Certainly an apprentice in a machine shop would quickly learn the subject until the use of both correct cutting speed and correct cutting lubricant would be second nature. The formula for obtaining the cutting speed required will be imprinted firmly in the mind of anyone who has worked as a turner or miller, and it is something that I am sure will never be forgotten.

LUBRICANTS

However, let us forget cutting speeds for the moment and concentrate on cutting fluids or lubricants. Firstly, let us ask ourselves why we ever need a lubricant when machining. The lubricant will have several effects. First, if sufficient is applied, it will keep the work and tool cool; second, it will make machining operations easier; and, finally, it will ensure that the work has a better finish. So I have given three good reasons for the use of lubricants but really they all start with reason number one, the heating up of tool and work. As the tool cuts into the work, a great deal of friction is created and friction of course means heat. It also means wear, and the wear that we are concerned with is to the cutting edge of the tool. We have the situation then that, as the tool traverses the work, so it creates friction but, as the friction is a rubbing action, the cutting edge of the tool is worn away. As the cutting edge loses its keenness, more friction is created and the cutting edge wears even more. It is a vicious circle.

If we use the correct lubricant, this reduces the friction and, with less rubbing, the tool remains sharper longer. With a sharp tool there is also less friction and so less heat is generated. As heat also tends to blunt tools, we have a two-fold effect of less friction creating less heat and less heat creating less friction,



The Belt and change gear system on a Compact 5 lathe. Permutations on the three pulleys give a wide range of speeds. The formula for obtaining each speed and thread pitch is printed on the front of the lathe.

with the result that the tool will last longer. This equation is complicated a little by the type of tool in use. High-carbon steel tools wear quicker and so create more heat than high-speed steel tools. The modern carbide-tipped tools do even better than the high-speed type and create even less friction because they do not wear so rapidly. The result is that the quantity of cutting fluid used also depends on the material that the tool is made of, as well as the material being machined.

This heat generation also has an effect on the finish of the work. Any work that has been turned, if placed under a microscope, will appear as a series of ridges like a thread. We aim to get these ridges so fine that they cannot be seen. Sometimes, of course, if care is not taken, the finished result will not need to be put under a microscope to look like a thread: it will appear that way to the naked eye. The finish is improved with the correct lubricant because of this lack of heat that is allowing the tool to skim over the work. Of course, there are other factors, such as the correct speed, a fine feed, a very shallow cut, and a sharp correctly profiled tool.

Cutting lubricants are not only required for turning, they are also needed for drilling and milling operations if these are to be carried out properly. Much of the same applies as far as tools are concerned. There is a need for the correct speed, a keen

cutting edge (except with brass, copper and bronze), and a fine feed.

Basically, that is why cutting fluids are needed and should be used. What type we use is a matter of individual choice, but, as the compact lathe will often be used in a home environment, some consideration must be given to how such lubricants are used, as they have a nasty habit of flying all round the place. As they are messy, and sometimes smelly, popularity will wane in the household unless care is taken. With this in mind, and having pointed out the need for the lubricant, the quantity used must be up to the individual. Ideally, work should be flooded but this is hardly a practical situation for most compact lathe owners. So, instead of flooding the work, we must find other ways of keeping the heat caused by the cutting operation to a minimum. Taking shallow cuts with a very fine feed is the obvious way. If $\frac{1}{8}$th inch or 3mm has to be removed from the job then, while no doubt the lathe would cope with this, it will be better to take three of about $\frac{1}{32}$in and two of $\frac{1}{64}$th or make the final one much less. Taking a break between cuts also reduces the heat and, if the lathe is left running, the rotation will have a cooling effect on the work. Generally in such circumstances, the tool will not get too hot.

Applying the fluid requires some thought. One way is to use some form of spray can, rather like the garden hand sprays. These apply a considerable amount of the liquid no matter how fine the setting, and when using a compact lathe I prefer other methods. A small brush will put the liquid exactly where it is required, although there may still be some splashing, and particularly when milling, one rapidly ends up with a somewhat bald brush. I now prefer to use a pipette, which is a narrow tube with a bulb on the end. At one time, the tube would be glass with a rubber bulb and this is of no use whatever. However, the modern versions are made of plastic and, although they have a limited life, they are so cheap to purchase that this is of no consequence. They can be purchased in any chemist at a price of a few pence per dozen. Using them is simplicity in itself. Just squeeze the bulb to fill up, and gently let out the required quantity right on the work.

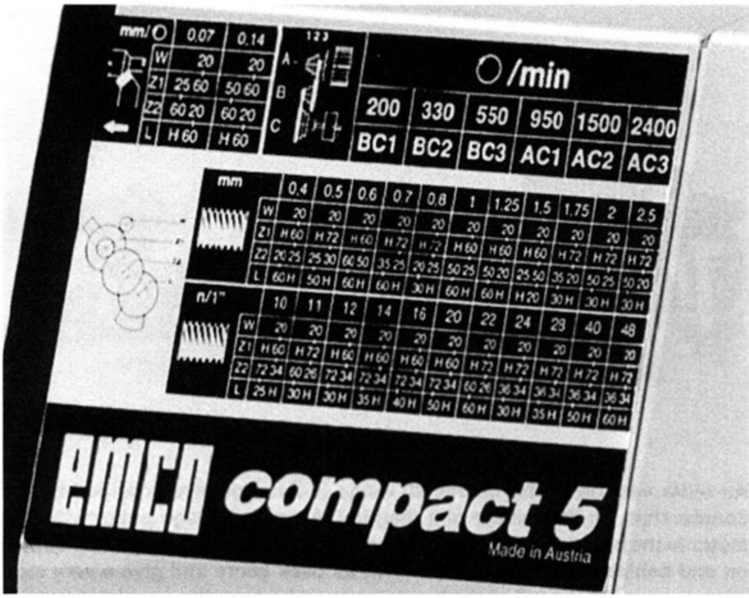
Let us then come to the actual cutting lubricant, and which is suitable for which metal. Steel of any sort requires a soluble oil. This is a special type of oil that mixes with water, usually at a ratio of about twenty parts water to one part oil. It is difficult to improve on soluble oil as a cutting medium on any form of steel. Brass, bronze, copper and aluminium can be machined

using paraffin, turpentine or white spirit. All work equally well. Cast iron should never, under any circumstances, be used with a cutting lubricant. The material contains graphite which itself is a lubricant. Cast iron actually tends to harden when machined with a cutting fluid. Brass can also be machined dry without too much ill-effect, and some of the softer bronzes will not suffer any ill effects from dry machining.

These then, are the basic cutting lubricants but nowadays there are numerous patent ones offered by various manufacturers which are excellent. It is impossible to go through the range available, and indeed this is constantly changing anyway, so it is as well to ask any good tool supplier for details of various cutting agents and to find one that suits. Many of these modern fluids contain solvents, and the cooling process is partially as a result of the evaporation of the fluid when it makes contact with the work. The advantage of this type of fluid when using a compact lathe is obvious: all the nasty mess simply disappears into thin air. We never get anything without paying for it, however, and the disadvantage comes in the form of fumes. In the small quantities likely to be used with a compact lathe, it is unlikely that such fumes will be harmful but it is as well to be aware of the potential, particularly if the operator suffers from some form of allergy. Most of these modern fluids are available in cans which will squirt the liquid in a fine jet onto the work, and so are very easy to apply.

For tapping purposes, a cutting agent in paste form is generally used. There is no doubt that the use of a cutting agent, or compound as they are generally called, is an aid when tapping and one should always be used. These compounds can also be used for turning operations and can be applied to the work before starting operations. They are very effective, and have the advantage that any residue remains in semi-solid form and can easily be wiped away after work is completed.

Various liquids can be pressed into service as cutting lubricants if nothing else is available. Water works very well but the obvious disadvantage here is the rusting that will occur to both work and machine. Lubricating oil works but is not as efficient as one would expect. Liquid silicone floor or furniture polish work very well and so does washing-up liquid. The latter is particularly effective on copper. We can also use semi-solid, household items. Butter and margarine are reasonable and lard is excellent. Floor and furniture polish again work quite well. It is worth experimenting to find a substance that suits your needs.

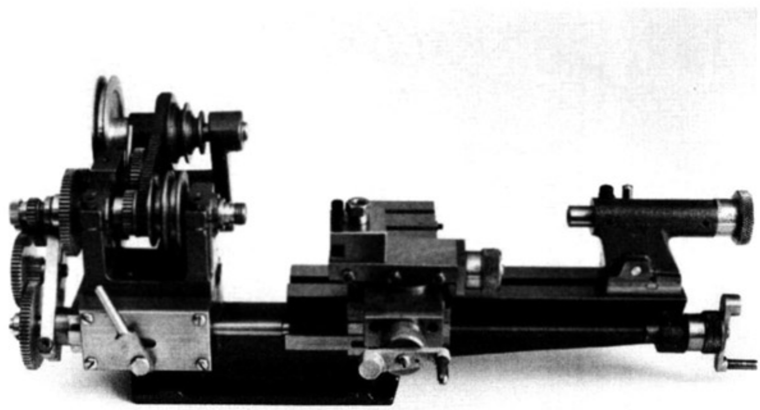


A chart showing how to obtain various speeds is printed on the headstock of the Compact 5 lathe.

CUTTING SPEEDS

One reason for getting as near as possible to the correct cutting speed is to generate as little heat as practical. To some extent, speed must be relevant to depth of cut and, if very heavy cuts are taken, then the speed will need to be slower than normal. The description 'cutting speed' applies to the speed of rotation of either the cutting tool or the work revolving in the lathe. So, if we are using a turning tool in the lathe, the speed needs to be in relation to the diameter being machined. If we are drilling or milling then the diameter of the cutter is the important thing. Basically, the smaller the diameter of either the work revolving in the lathe or the milling cutter or drill, the faster the rotation will be. It will vary according to the metal in use. One further point is that if we have a tool such as a fly cutter in use, then the cutting speed will relate to the circumference of the circle described by the cutting edge.

All materials have a cutting speed which can be supplied by the manufacturers. If we take this speed, which may be in feet per minute or millimetres per minute, and multiply it by pi x diameter of the work, then divide by twelve in the case of imperial working or one thousand in metric, we have the correct cutting speed for our machine. In the case of a milling



An older version of the Cowell 90 range has the pulleys arranged from a countershaft on the middle of a mandrel. A variable stage pulley from the motor to the countershaft increases the range still further. The gears mounted on and behind the mandrel are known as back gears and give a very slow speed range. To the left of the headstock can be seen the gear train used in obtaining the automatic feed, and the lever in front of the headstock operates this feed.

cutter or drill, we take the metal speed and multiply by pi x the cutter or drill diameter and divide as before, and we get the speed at which our cutter or drill should rotate.

This is all very well, except that the average compact lathe owner will not have the faintest idea of the correct speed of cutting for the metal. As he or she will purchase it in small quantities, and frequently get it from a number of suppliers, there is very little chance of getting the correct information. Metal comes in a vast range of qualities and, indeed, a quick reference to a catalogue showed me nineteen different forms of mild steel, each with its own cutting speed.

Obviously, then, we need a compromise and that we can have without any danger of spoiling the work. As the situation is so complicated, I have not tried to suggest a cutting speed for every type of material and allow readers to work out the rotational speed for him or herself. I have made a chart that works quite well and suggest that readers use this (see Appendix 1). It is not possible to get the speeds correct for all lathes, as each will have its own range of speeds. The table has been prepared with slightly lower speeds than required, and there would be no harm in slowing down still more to suit a particular machine.

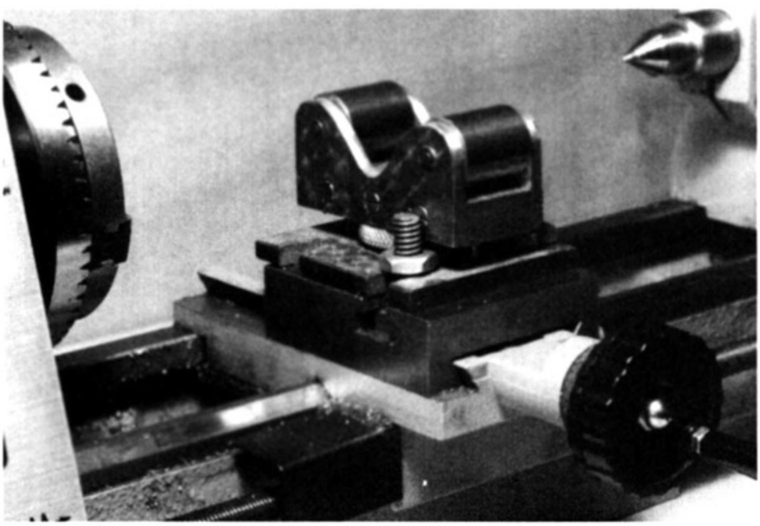
As experience is gained, the operator will need to rely less

and less on a table to get the cutting speed. If things are right, the lathe will cut smoothly and evenly and, if it does this, the speed is satisfactory. Remember, though, no one aspect of machining will get the work right. For turning we need correct centre height, correctly shaped and sharpened tool, and a reasonable feed as well as the right cutting speed, in order to get good results. These results will be improved still more with a good cutting lubricant.

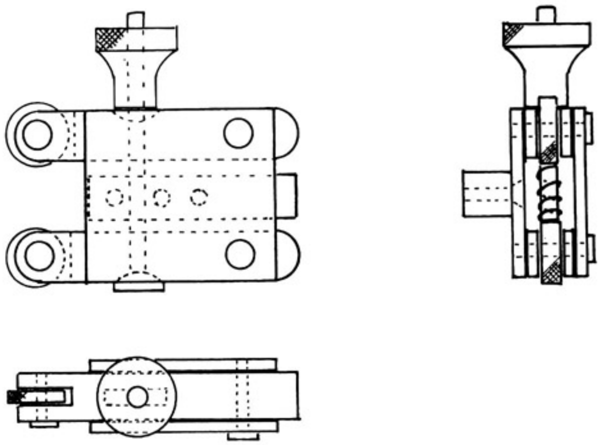
19 USES FOR THE COMPACT LATHE

Most people who buy a lathe will do so in an attempt to further a hobby of which they already have some knowledge. There are, no doubt, many who just fancy the fun of operating a machine and will want some idea of what can be made with it. First of all, my opinion is that it is worth getting some metal and practising some of the techniques described in this book. If mistakes are to be made, then it is better to make them at a time when it is not important, rather than ruin some nice project through lack of knowledge.

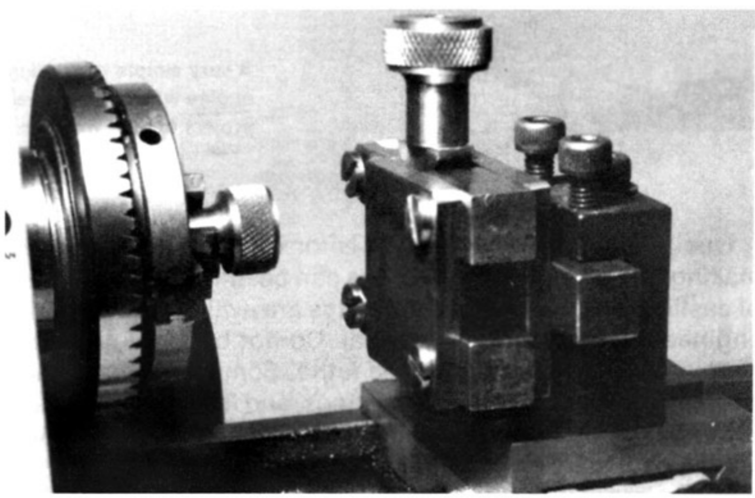
The lathe can be used for all sorts of little projects so let us look at some. Small jobs around the house can be accomplished. Odd pieces needed for various household items can be made, little things as a rule that cannot easily be purchased suddenly become easily within one's scope.



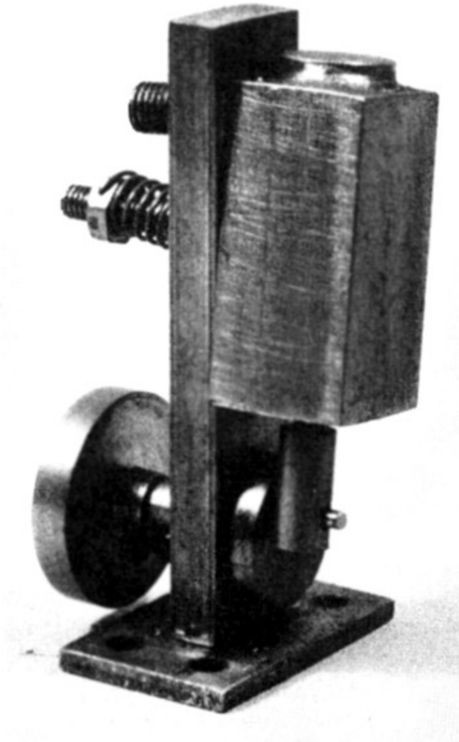
An obvious use for the lathe is to make extra tooling to increase its capacity. The photograph shows a simply made filing rest.



Knurling is a process of putting a pattern on metal. This both makes it lookattractive and helps one to get a grip on adjusting knobs etc. The drawing shows three views of a simple home-made knurling tool.



The knurling tool in the lathe. To operate it the wheels are placed over the work and tightened as hard as possible using the knob on top of the tool.The lathe is started at a slow speed and the knurling tool wound along the work and then back to the start very slowly. The operation is then repeated with the adjustment a little tighter until a satisfactory pattern is made. Knurling wheels come in pairs to make diamond or straight patterns. They are very hard and small bronze bushes should be inserted in the bore to prevent them rubbing through the pins that hold them.

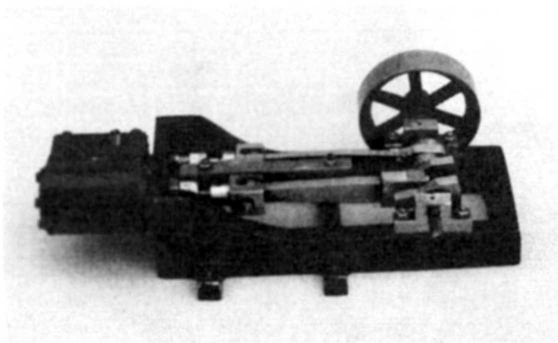


A very simple oscillating engine which is an ideal project for any beginner.

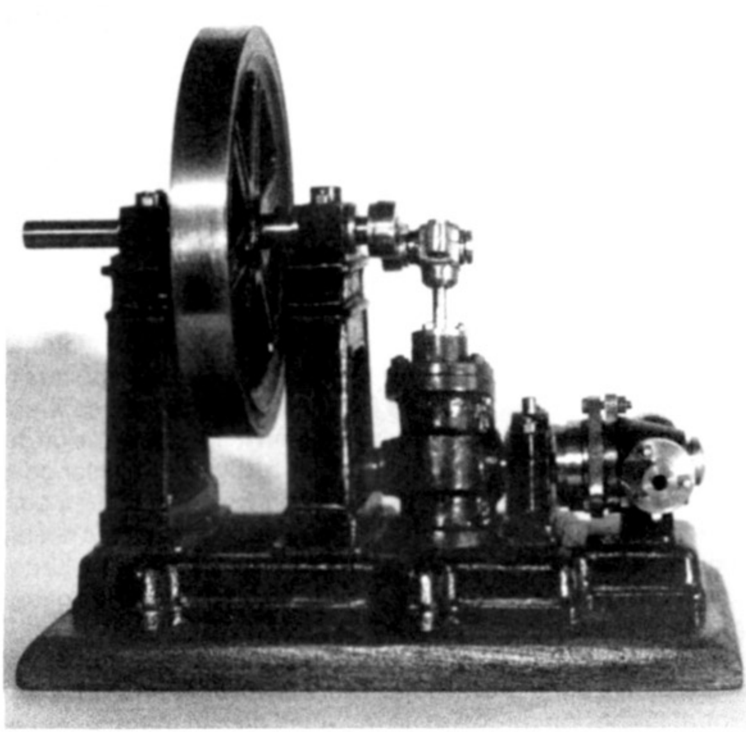
One of the more obvious uses is for various forms of model making. Stationary steam engines can be made from a mixture of castings and basic metal. Castings are available at all model engineering suppliers, as is metal. Do not be too ambitious - keep within the capacity of the lathe. Some small stationary engines can be made without castings, and for a beginner there is a great deal to be said for making a small oscillating steam engine as a starter.

Model internal combustion engines vary in their complexity. They, too, are made from a mixture of castings and stock material. Plenty of drawings are available, as are sets of castings. There is no reason why a model should not be fabricated completely, and many winners of the various classes at the Model Engineer Exhibition have been made in this way.

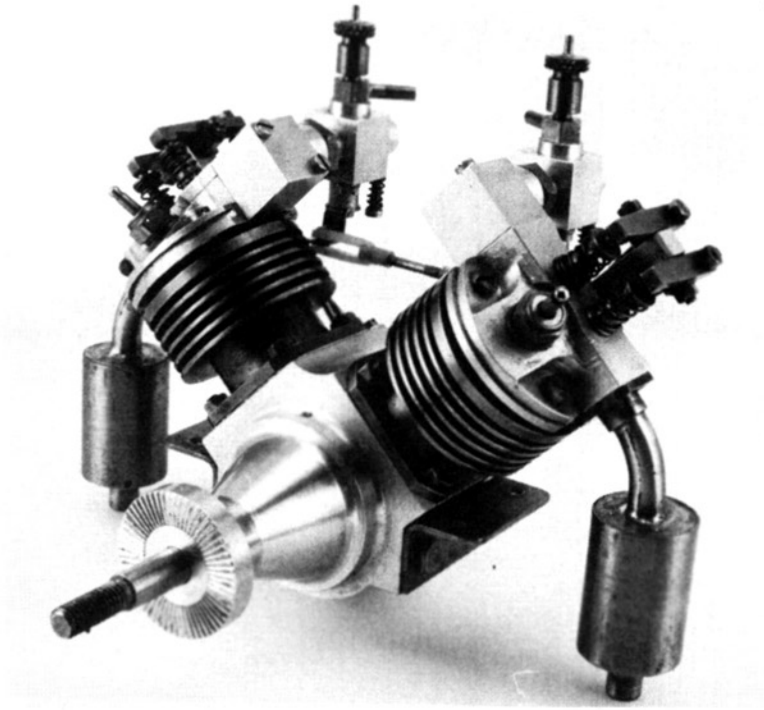
Model railway locomotives lend themselves particularly well



A slightly more advanced but still very simple horizontal stationary engine.



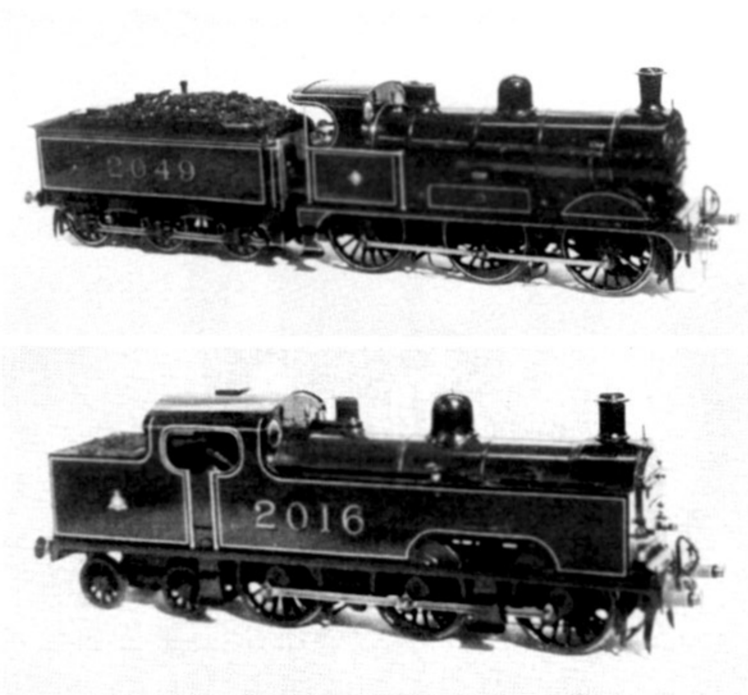
A more complicated scale model of a stationary engine by Hick and Son as exhibited in the 1851 British Trade Exhibition.



A model aircraft engine. There are many designs of internal combustion engines available which can be made on the compact lathe.

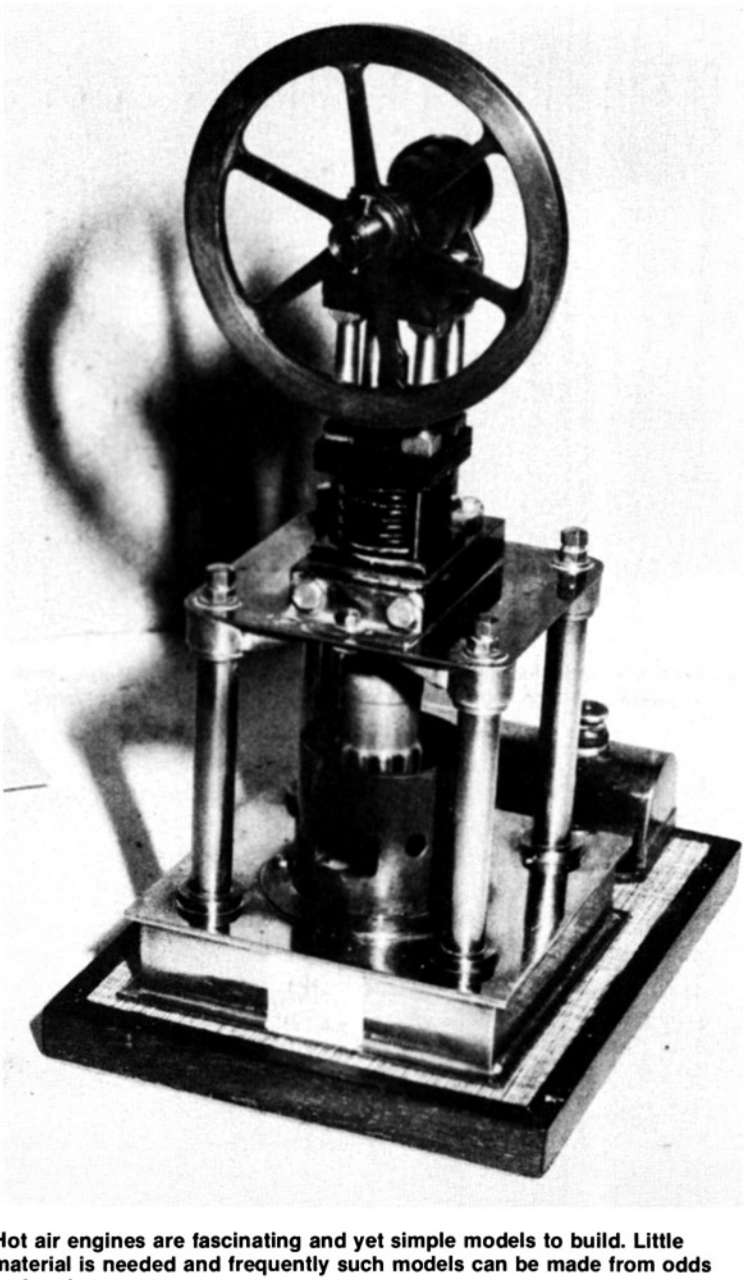
to construction on a small lathe. Models in the smaller gauges from "O" to gauge One are well within the range of the machines. While most work will be from basic stock material, there are castings available for wheels etc.; lists of suppliers of drawings and castings can be found in most magazines which deal with this aspect of the hobby. When it comes to the larger gauges for locomotives which will actually haul passengers, then we must think small. It is no good trying to build a one-inch-to-the-foot scale Pacific locomotive, as the lathe is not big enough. It will cope easily with two and a half inch gauge models, and I have built a very small three and a half inch gauge one on such a lathe.

Model boat fittings become comparatively easy things to make when a lathe is available. There is no more need to spend a lot of money on out-of-scale moulded plastic fittings; proper scale brass ones can be the order of the day. The engines to power the boats can also be made.

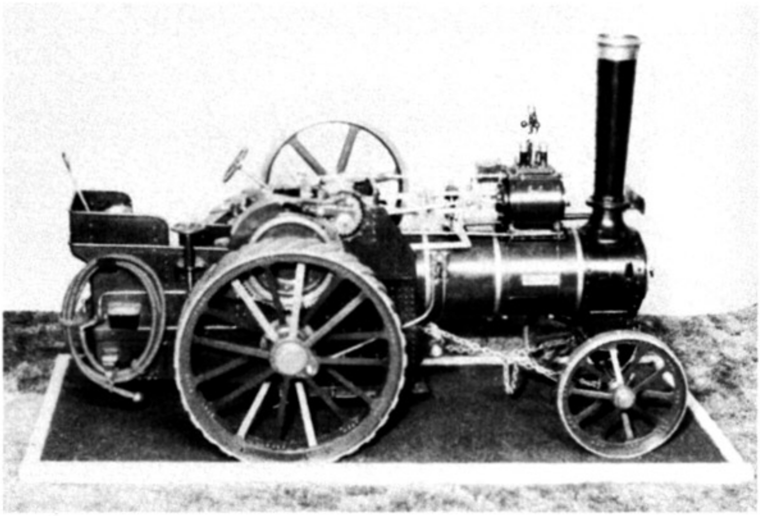


Two very fine model locomotives in 'O' gauge built by David Moore. Both run on steam and such models are ideal subjects for the compact lathe.

Fittings for a model boat such as this will enable much higher standards to be set in marine modelling.



Hot air engines are fascinating and yet simple models to build. Little material is needed and frequently such models can be made from odds and ends.



Small traction engine models are not beyond the scope of the compact lathe, but models only up to a scale of one inch to a foot should be attempted.

Where fittings are concerned, it will largely be reproduction work as several of each will be needed. Use the ideas contained in Chapter 16 and fittings can be turned out very rapidly.

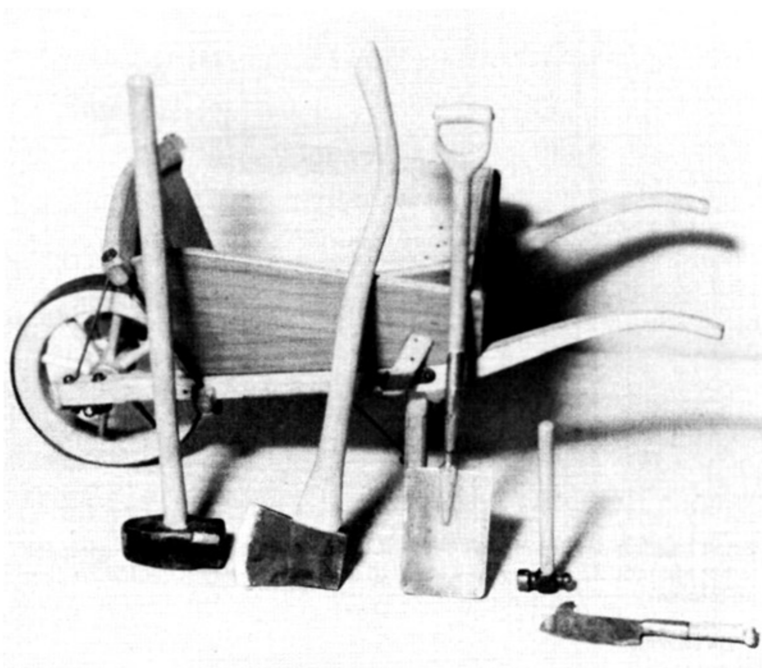
How about a hot air engine? These certainly lend themselves well to being constructed from a small lathe. They can be made from odd scraps of metal and are not difficult. The fascination of watching one work is worth the little time involved in the building of it.

The model soldier enthusiast will find many uses for his or her lathe. All sorts of armament and fittings can be made, as can parts for motor vehicles and tanks. How about spacecraft parts? They can be fabricated to represent the real thing very easily.

Parts for dolls' houses are among the long list of things we can make. I have often been asked to make door knobs, light fittings and similar things for people making dolls' houses. Surely, in this case, the list is almost unlimited.

Not everyone wants to make models, of course, but there are many decorative things for the family. Small brass candlesticks, desk sets to house pens and pencils, paper knife handles, crib sets, and chessmen are but a few that come to mind.

Once the lathe is yours and you have mastered its use, then whenever you intend buying something ask yourself if you can



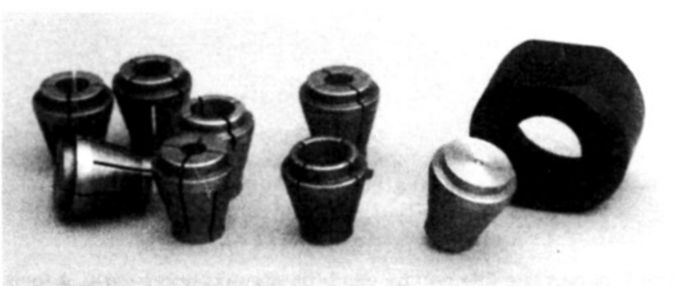
Something very much more unusual. This wheelbarrow and tools made by Ralph Ley combined hand skills with work on a compact lathe.

make it. Many times the answer will be yes, and the object, when made, will have far more value to you than one that has been purchased.

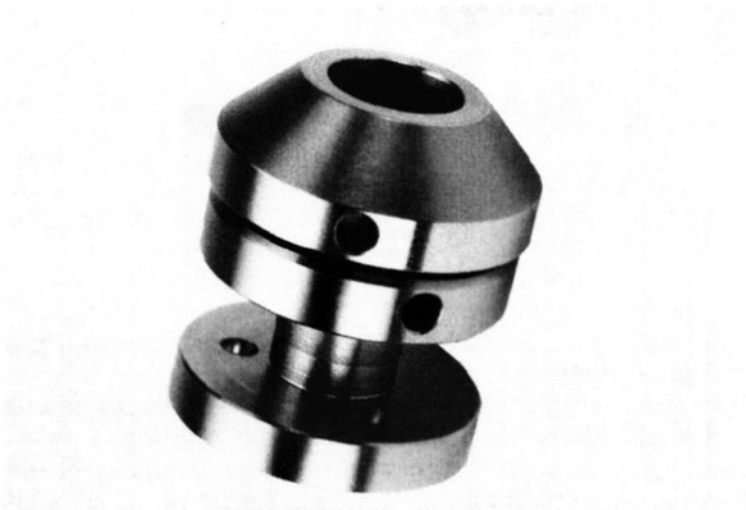
20 CLOCKMAKING

Clockmaking is possibly one of the major uses to which compact lathes are put, and I am quite sure many are purchased with this as the main purpose. All the lathes referred to are capable of good work in this field, although only the Cowell CW is built with clockmaking as the primary aim. There are a number of other lathes available which are made purely for clock and watchmakers, but these have not been mentioned as they are very expensive when purchased new and, although they can be bought second-hand, they are not easy to find. Many of the watchmakers' lathes are now no longer made, compact lathes having taken their place.

What, then, do we need for clockmaking? For a start, we must have a reasonably accurate lathe, with a very high top speed. There must be facilities for dividing, as a lot of the work will involve making gear wheels and accurate division is essential. It is also useful if a hand turning rest is available. Some of the fancy brass work found on clock cases can only be turned with a hand graver, and to use one of these a proper rest is required. Such a rest can be made if one is not available, but ideally a casting would be needed for its construction.

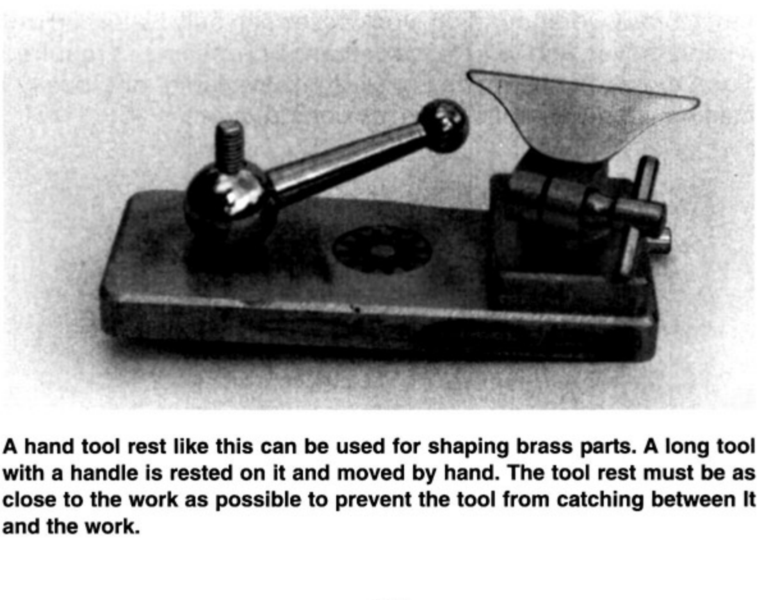


Collets such as this set are very useful when making clocks. They are an aid to accuracy as well as being convenient where several identical components need to be made.



A collet by Emco. It is closed on the work by simply closing the nose cap.

Some way of carrying out milling operations will be a help but these facilities need only be small. A filing rest is also very useful for this type of work. Cutters will be needed to cut the teeth on the gears. These are of a special shape, and cutters o the right type are made specially for the purpose. Once again lack of such cutters does not debar anyone from clockmaking

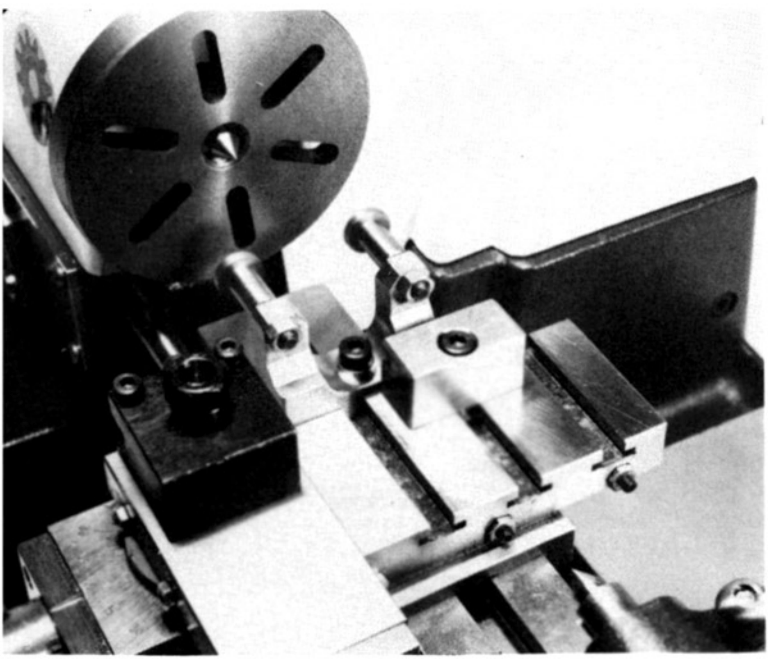


A hand tool rest like this can be used for shaping brass parts. A long tool with a handle is rested on it and moved by hand. The tool rest must be as close to the work as possible to prevent the tool from catching between It and the work.

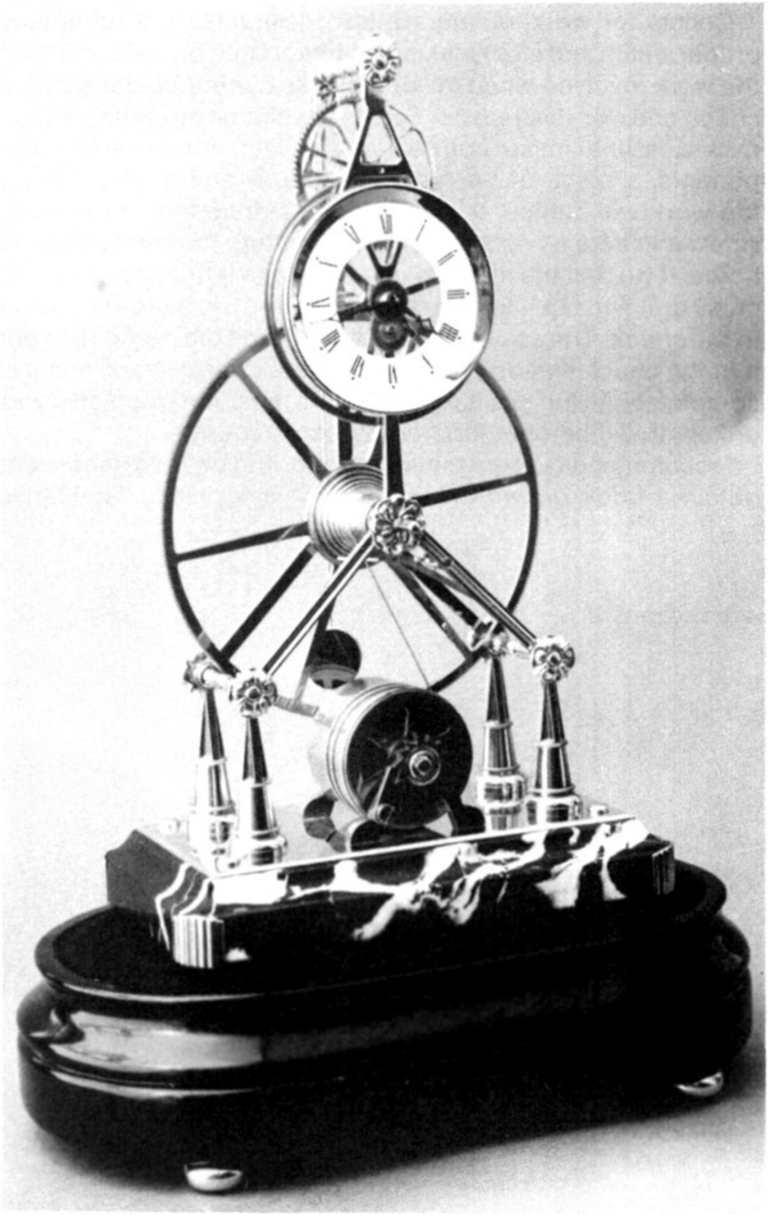
as suitable ones can be made but, in many ways, there are advantages in purchasing them.

Collets for workholding are also desirable, and preferably proper watch and clockmaking collets should be used. Much of the work involved when making clocks cannot be done with a chuck and, for this reason, collets are almost essential. Again, it is possible make collets, and in fact, for one-off components, a piece of bar held in a chuck and drilled to hold the work will suffice. It must be cross-drilled for a retaining screw and here it becomes a case of putting the cart before the horse. If we drill the material and then take it from the chuck to cross drill and tap it for the screw, it cannot go back accurately in the chuck. The answer is to cross drill and tap it, and then put it in the chuck and drill it. Leave it there until all work with it is completed. As long as it remains in the position in which it was drilled, it will be one hundred percent accurate.

I recommend readers thinking of starting on clockmaking to obtain a book or two on the subject in order to familiarise



A filing rest is also a must as many parts need to be filed while still held in the mandrel. This is an ingenious device from Cowells. As the cross slide is wound in so the rollers are raised in height, this gives a particularly fine adjustment to them.



A very fine example of the clockmaker's art is this French clock which was made by Jack Donaldson.

themselves with it. It is not as complicated as is imagined, and the accuracy required is no greater than that needed for many modelling projects. But it is a subject that needs to be read up before making a start.

PART 2

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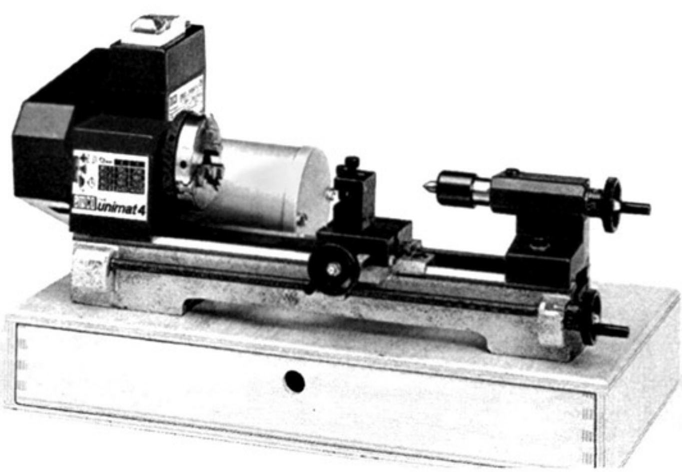
21 UNIMAT 4

The Unimat is possibly the best known of all the compact lathes having been in production in one form or another for over fifty years, a great many of which are still in regular use and the Unimat-4 is a development of the various models, the company having listened to owners and made improvements in line with their suggestions. The result is a rugged machine with a cast iron bed that has ground vee guides, that is very accurate and hard wearing.

The centre height is 46mm and the distance between centres 200mm, the swing over the bed is 92mm and a diameter of 62mm can be machined over the cross slide. The machine has a range of eight speeds from 130 to 4000 rpm, unlike many of the compact lathes the nose spindle is threaded 14 x 1mm. The tailstock, which is made from cast iron is bored for a 0.5 Morse Taper and is operated by a hand wheel, with graduated dial. The basic package for the machine includes a scroll type three-jaw chuck, hard centre



The Unimat 4, a machine that with modifications has stood the test of time and of which there are many thousands in use.

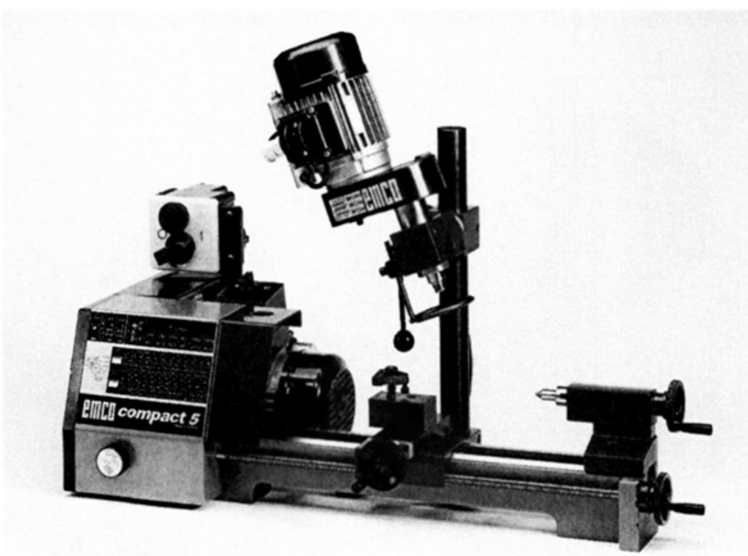
and tool post, and a comprehensive set of operating instructions.

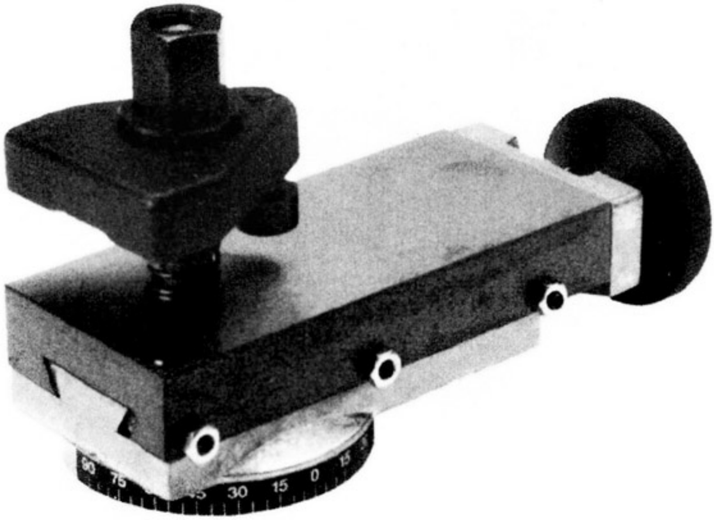
Possibly one of the biggest advantages of the machine is the vast range of accessories that are available, they are far too numerous to be detailed but as well as such items as a milling column, that bolts directly to the bed of the lathe, clock making and woodworking kits, there are various holding and dividing devices, there is thread cutting gear and numerous tools for machining. It is the ideal set up for anyone wanting to build a small machine shop in gradual stages, as it only weighs six kilograms it is very easy to store should it not be possible to find a permanent place for it.

EMCO COMPACT 5

Really speaking the Compact 5 falls a little outside the parameters set for models to be dealt with in this book, but as many of the accessories for the Unimat 4 are common to the Compact 5 it was considered to be well worth a mention. In many ways the lathe is basically the same as the Unimat 4 in its form of construction but

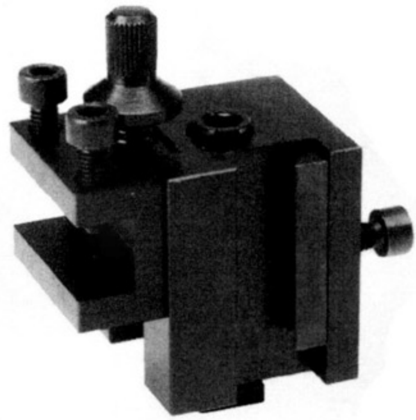
The Emco Compact 5 very similar to the Unimat 4 but just a little larger. The machine is seen here fitted with a bolt-on milling attachment that fits both models. A large number of accessories are available for both machines, some specific to one or the other but generally interchangeable.





A useful accessory for the two small Emco lathes is this top slide that can be set at an angle for taper turning.

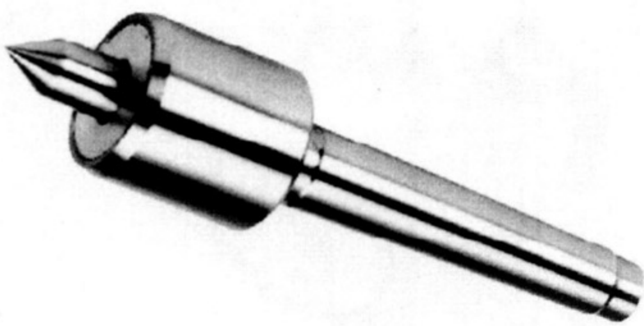
A rotary attachment that is available for use with Emco lathes, the thread on the mandrel fits lathes by that manufacturer but could be adapted for other purposes.



A height adjustable tool post is available for either the Unimat 4 or Compact 5 lathe.

the centre height is 65mm and the distance between centres is 350mm. In addition the headstock accepts a No. 2 Morse Taper, although the tailstock is still reamed for a No. 1. The vertical milling column specified for the Unimat 4 also fits the Compact 5.

Like the Unimat 4 it is rugged and capable of hard work and a long life and with the large range of accessories it too is an ideal model for anyone wishing to start a small workshop. In spite of the increase in size and the fact that a larger motor is fitted the machine still only weighs twenty kilograms and so can easily be stored in a cupboard or under a bench when not in use.

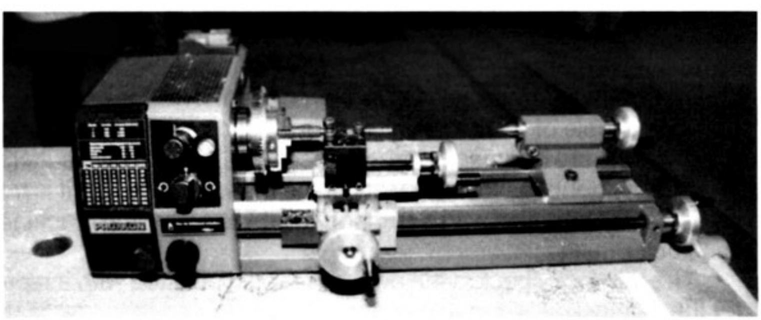


A revolving centre that fits both lathes and is a very useful accessory.

22 THE PROXXON PD 230/E

Of European manufacture the Proxxon PD230/E (and its larger counterpart the PD400) have long been favourites with model makers and horologists in mainland Europe and is rapidly making inroads in the British market. The PD 230/E appears to have been adapted from the Toyo 210 and in so doing a number of improvements have been made to what was already a very fine machine. Constructed with a ground, solid cast iron bed with "V" slides it has a centre height of 28mm over the cross slide, distance between centres is 230mm and a cross slide travel of 60mm. The spindle bore is 10.5mm and spindle speeds of 300, 900 and 3000rpm are available via a pulley system. This range is further supplemented with an electronic speed control, which means that in fact any speed between 100 and 3000 rpm are available. The mains motor that drives the machine is fitted with a forward/reverse switch.

In common with many small lathes of this type the spindle has a 0.5 Morse Taper, the fact that it runs in sealed ball races gives it a very high degree of accuracy (the manufacturers claim 0.01mm) and that spindle wear is unlikely to ever be a problem. There is an automatic feed that gives movements of 0.05 and 0.1mm per spindle revolutions and a series of change wheels give thread pitches of 0.5; 0.625; 0.7 ; 0.75 ; 0.8; 1; 1.25 and 1.5 mm., a range



The Proxxon PD230/E lathe, a useful machine very similar to the now out of production Toyo 210

that will almost certainly include every pitch likely to be required for the work that the lathe is intended for. A change wheel chart is printed on the front of the headstock cover.

The standard top slide arrangement is unusual as it has "V" guides for the tool post, which is fitted with a lead screw, this allows a much longer travel than is usual and as it can be set over, there is a capability for a reasonable length of taper turning. The dual tool holder has facilities for holding two tools up to 8mm square but only accepts one tool at a time. Two cap headed bolts, mating with gib strips allow adjustment for the "V" arrangement with the top slide and a third bolt is used for locking the post to the slide if heavy work is being carried out. The slide arrangement and its extra length means that the wheel and handle used to move the top slide are larger than is often the case.

The tailstock is a solid casting and fitted, like the headstock with a socket for a 0.5 Morse Taper, a suitable hardened centre is included as standard. The tailstock is locked to the bed with a cap screw and a cap screw is also used for locking the barrel. A large wheel and handle is used for operation and operates a 1mm pitch screw. This in conjunction with a dial graduated into 40 divisions allows a movement of 0.025mm per division. This is common to all hand wheels on the machine and all the dials are re-setable.

As standard a three jaw scroll chuck is fitted and this is operated with a normal type of key. It has a capacity of 24mm normally, but as the jaws are reversible there is a real capacity to accept work up to 68mm diameter. This type of chuck is common to nearly all small lathes.

ACCESSORIES

A number of useful accessories are available and these include a mill-drill attachment that bolts to the rear of the lathe bed. The milling kit includes a table that is fitted in place of the lathe top slide, it has three tee slots, the head of the mill-drill can be set at an angle should any angular work be required. It has its own motor and with a table of 110 x 70mm there is a good capacity for milling. Three collets are included in the kit to accept 6, 8 and 10mm cutters. There is no doubt as to the quality of the mill-drill as in fact it is the same as one supplied with a compound table as a milling machine.

Tailstock Chuck

The tailstock chuck is the normal keyed type fitted with a taper for the tailstock, it is capable of accepting drills and other items up to a diameter of 10mm. While this might be suitable for a centre drill it is rather larger than one might wish to use in conjunction

with the shortened taper, where in reality 6mm would be about the maximum. As already mentioned Larger drilling is best done with the drill supported in a centre and aligned via a steady, while gripped with a clamp or something similar as described in Chapter 12.

Collets

A good collet system is also included amongst the accessories that are available and no doubt will find favour with clockmakers, the system is more or less standard and uses a closing nut. The collet set consists of eight collets of the most used sizes.

Faceplate.

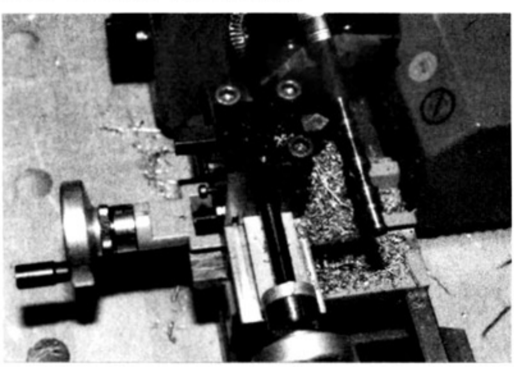
At one time when one bought a lathe it came as standard with a faceplate and no chuck. Regrettably it is now common practice to supply a three jaw chuck with the faceplate (if one is available) to be obtained as an accessory. Old time turners would be horrified at the thought, but at least with the Proxxon a faceplate is available, something that cannot be said for all makes. In this case it is bought as a centre turning kit and comes complete with soft and hard centre and a drive dog.

Four Jaw Chuck

The four jaw chuck is a good substantial one that appears capable of a great deal of hard work. It is of the geared scroll type and has reversible jaws. The maximum capacity is given as 80mm, which one assumes is diameter.

Fixed Steady

Although no doubt many readers would rather make this type of accessory for themselves, a fairly substantial fixed steady is available for those that wish to buy one. There is no facility for using a moving steady and this is something the purchaser would have to make for himself.

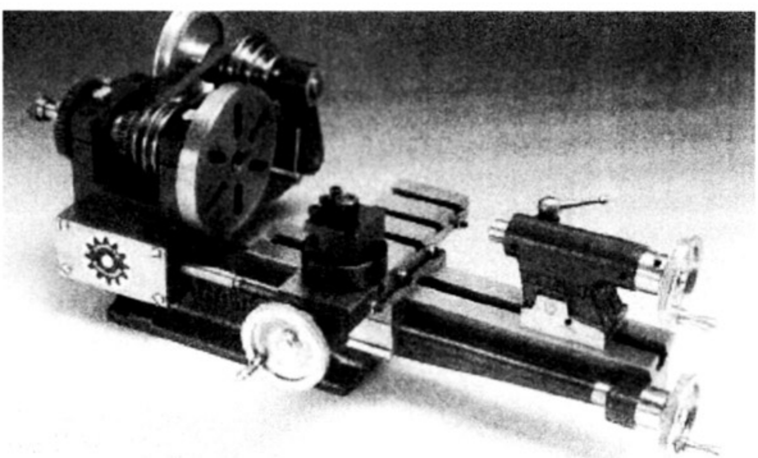


An overhead view of the Proxxon PD230/E showing the neat arrangement of the adjustable top slide.

23 THE COWELL RANGE

Originally made in Norwich, England and called The Perris, when the owner of the company making the lathe died construction was taken over by Cowell Ltd, which was also Norwich based. After a short while many improvements were made on the original design and a range of accessories were produced, the company also producing a small milling machine. Construction has since moved to Colchester, England and there is now a range of three machines all of which are very popular.

All the models are basically the same dimensions, with a centre height of 45mm over the bed, but as the bed has a gap the available swing is a useful 120mm, the distance between centres is 200mm. The beds are of cast iron and are ground flat, where fitted motors are continuously rated where as many small lathes have motors that are time rated and need to be switched off after a period of use. Except in the case of the clock-making model, movement of the saddle is via a hand wheel that is fitted with a graduated collar



The basic Cowell 90 lathe is supplied with a faceplate and tool post but without motor. A useful feature of the machines is the extra long cross slide.

at the end of the lathe and the lead screw gives an automatic feed.

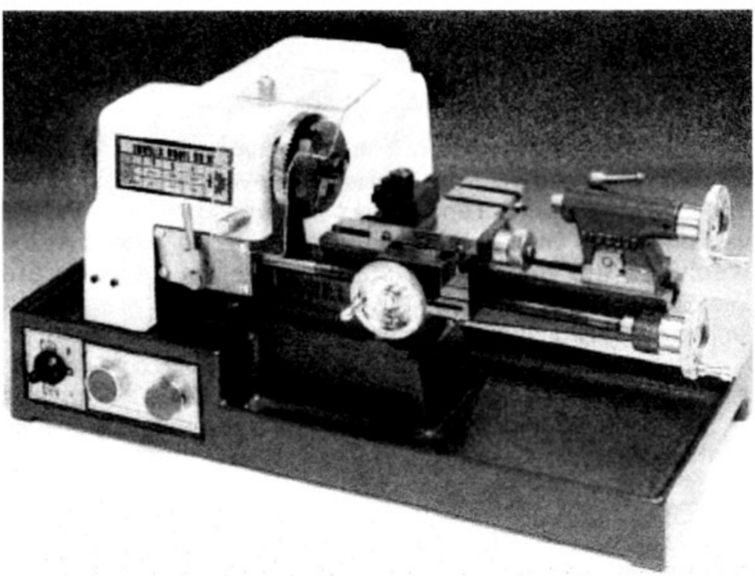
The cast iron tailstock is fitted with a locking handle and both that and the headstock are reamed for 0.5 Morse Tapers, in common with most compact machines and unlike most machines of this size can be set over for taper turning, thus allowing longer tapers to be made than is possible when using the top slide.

COWELLS 90E

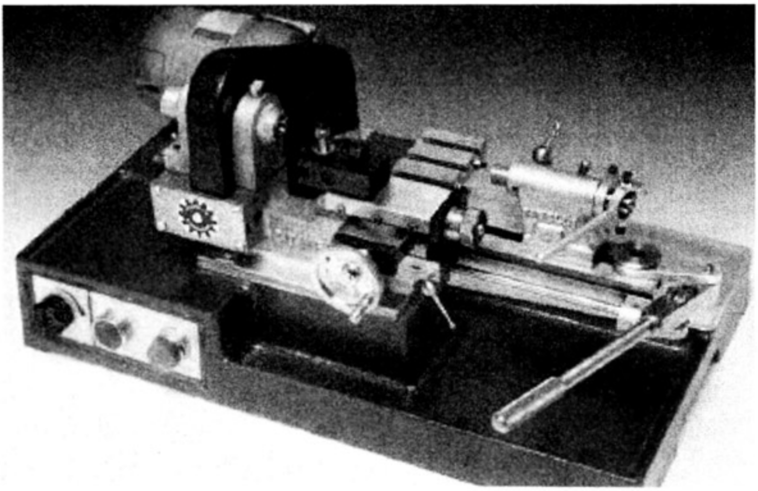
The basic machine called the Ninety is really a basic set up it being left to the purchaser to decide what accessories are required. In many ways there are advantages in this, many machines are sold with three jaw chucks and the use of these is strictly limited to machining round and hexagon bar, buying a basic machine gives one a chance to start with a four jaw independent that is far more useful. A motor is not supplied with this model.

COWELL 90ME

The Model Engineer version is the 90 ME and comes complete with automatic release on the lead screw and swivelling top slide, as well as a back gear and change wheels as standard, there is a



The Cowell 90 ME model has a metal base that also acts as a drip tray it is designed with the model engineer in mind.



The 90 CW is made especially for the clockmaker and has been adapted accordingly

range of speeds from 60 to 1100rpm. A feature of this and all the other machines is the nicely engraved metal hand wheels that give a nice positive feel to their operation. Another useful feature is the long top slide that allows a rear tool post, which is available as an extra to be used.

COWELL 90CW

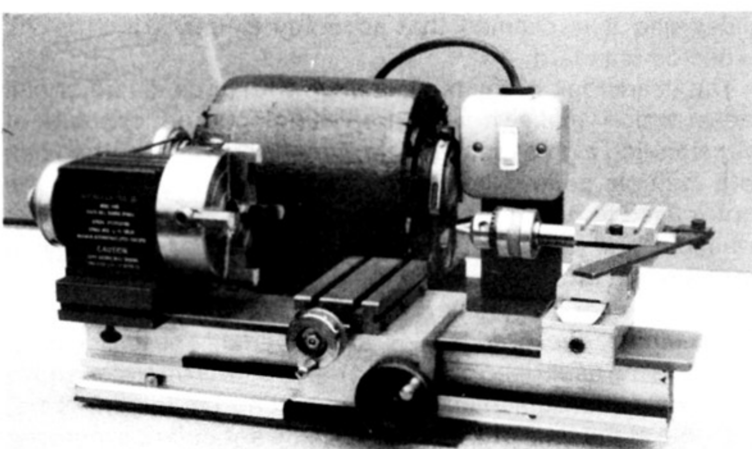
A special machine, the 90CW is made for clockmakers. The lead screw is dispensed with, instead there is a lever operated top slide. The lead screw, self act and screw cutting mechanism for the ME version can be fitted to the CW if one so wishes, indeed as the machines are made on a modular system all parts are interchangeable, which give the buyer the best of all worlds. A limited but very useful dividing arrangement, is fitted as standard.

There is a wide range of accessories available, covering just about any situation likely to arise and even includes such items as an automatically adjustable filing rest and a wheel-cutting spindle for the horologist.

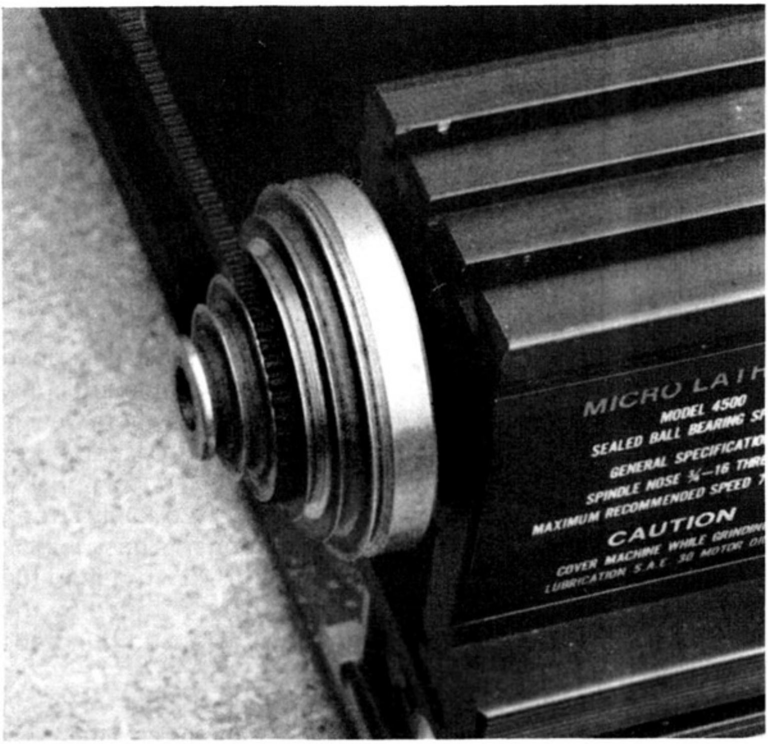
24 THE PEATOL MICRO LATHE

The Peatol differs considerably from the other lathes described as some of the components are made from alloy extrusions. Heat treated alloy steels are used in all situations where wear is likely to occur. There is nothing wrong with this method of construction – such extrusions are used in the space industry and if they are strong enough for that they are certainly strong enough for a lathe. The use of these components has meant a considerable saving in cost, for what is a very rugged little machine. The quality of the machine is demonstrated by the fact that it has been available for many years, and hundreds have been sold.

The centre height is $2\frac{1}{4}$ inches and the distance between centres $9\frac{3}{4}$ inches. No motor is supplied but any $\frac{1}{6}$ or $\frac{1}{4}$ horse power motor will drive the machine and a second-hand washing machine motor is ideal for the purpose. The lathe suppliers can also supply motors if required. The lathe is



The Peatol lathe shown here fitted with a motor and operational switch.



The drive on the Peatol lathe is via a very fine toother belt.

supplied in easy to assemble kit form with a choice of either a three or four-jaw chuck. Provision is made for adjustment to all slides and it is claimed that accuracy to 0.0005 inch is the expected standard.

The headstock of the lathe is fitted with large diameter ball races which make it very free running, and capable of withstanding a great deal of wear. Drive is by a fine toothed belt to a multiple pulley, the range of speeds will depend on the motor used to power the machine. Spare belts and pulleys are available and this would enable a purchaser to put in a countershaft and so increase the speed range further.

Large, well graduated handwheels make for easy working of the machine, the graduations are imperial. The cross slide works via the usual lead screw, but the saddle is operated with a rack and pinion mechanism. Gear cutting equipment is not available at the time of writing but will be a standard accessory in the future.

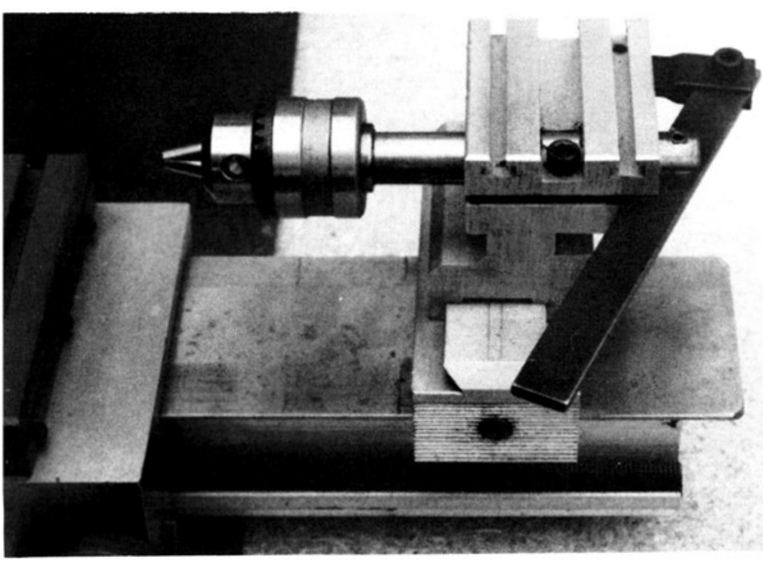
A number of accessories are available and these include a

tailstock, this not being part of the standard equipment. It has a vee slide to allow adjustment across the width of the lathe bed and so allow it to be used for taper turning. The tailstock is lever operated and is very sensitive. The arrangement for changing centres and drilling chucks is rather unusual, the whole spindle on which they are mounted is changed. This is no more difficult than changing them in the usual way and has the advantage that there are no morse tapers to wear. Making tailstock accessories is much easier than it is for the more traditional type of fitting.

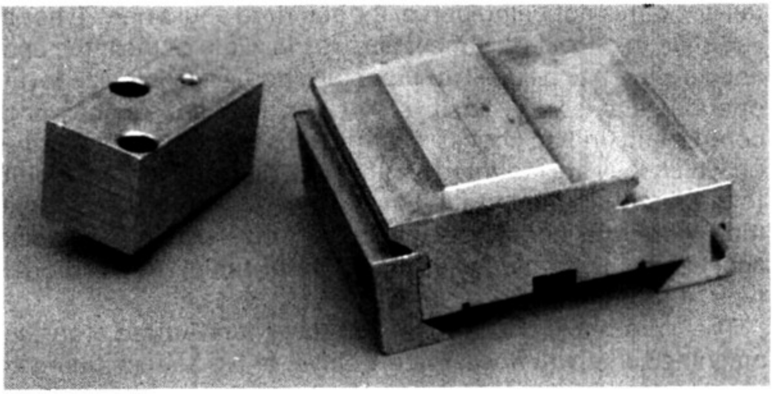
The three-jaw chuck has soft jaws and these can be machined true when wear takes place, or if a special fitting is required for any particular component. Spare jaws can be obtained and it is also possible to get a collet set.

A compound or top slide is included amongst the listed accessories and is easy to fit. This allows angular or taper turning over short lengths and saves the necessity for setting the tailstock over. Also included with the accessories are packing blocks which allow the headstock and tailstock to be lifted and so increase the capacity of the lathe.

The vertical slide is, by compact lathe standards, quite massive. A machine vice is incorporated with the slide. The sheer bulk of it means that many of the problems associated



The lever feed tailstock is available as an extra.



Raising blocks make it possible to raise both headstock and tailstock, and so increase the capacity of the lathe.

with using a vertical slide are eliminated. This too has a nice large operating handle and good clear graduations.

The Peatol Micro Lathe is available from Peatol Machine Tools, 19 Knightlow Road, Harborne, Birmingham, BI7 B95.

25 OTHER COMPACT LATHES

The lathes that have so far been referred to are those that are easily obtainable, in addition there are a number of virtually identical models made by the same far eastern manufacturer that are sold under a number of different brand names. All are of reasonable quality but the accessories contained in the initial sales package varies according to the supplier. The following pages give details of a number of models that are frequently available as used models. All are machines that have stood the test of time, but have been withdrawn from the market because of modern commercial trends.

FLEXISPEED

The Flexispeed is a long time favourite amongst model engineers and horologists and although it has been out of production for many years it is surprising how frequently a model comes on the used market, probably because it was at one time so popular and a large number were sold. A good rugged design, it is really a scaled down version of larger types of machine.

THE TOYO LATHES

Two very useful high precision lathes were marketed under the brand name of Toyo and may be found on the used market. Made in Taiwan but marketed by the Japanese Company both are of high quality although very different in style.

The ML1 did not stay on the market for very long and it is hard to understand why as it was a particularly rugged machine, in fact it is just possible that its demise was due to the very ruggedness that was based on a box type bed. Incorporating a built in motor and self-acting feed to the saddle, it had a full set of change wheels for cutting metric threads. Both tailstock and headstock accepted 0.5 Morse Tapers, the latter being bored right through to a diameter of 10mm. There is a range of six speeds via a system of pulleys and belts.

The 210 is very similar to a number of models that are or have been available both in size and shape and is a well engineered machine, unlike the ML1 it has a more conventional cast iron bed with ground vee slides. Basic equipment includes a three-jaw scroll type chuck.

THE SIMAT 101

This little lathe comes as a basic kit and is designed for home assembly. While the thought of assembling a lathe might seem rather frightening to the newcomer, it is a very easy job. It is made even easier by some excellent illustrated instructions. There is also quite an advantage in assembling one's own machine as it enables the owner to get to know the construction of the lathe and how things work, which later will assist in learning how to use the machine. There is no motor supplied but there are plenty of small motors available at reasonable prices. A countershaft to enable one to get a larger range of speeds is desirable and this is available as an extra. The lathe is of 2in centre height and is 12in between centres making it somewhat larger than most compact lathes. The mandrel has a screwed nose and the lathe comes complete with faceplate. Chucks are available as extras and these follow the Toyo pattern and are supplied with a screwed adapter that is bolted to the chuck. There is a good range of accessories available including steadies, rotating centre, vertical slide and tailstock chucks.

The mandrel and tailstock accept 0 Morse tapers and so accessories from other lathes are interchangeable with the Simat 101. The lathe has a self-acting mechanism for operating the saddle, and screw cutting gears, (while not available at the time of writing), are on the agenda and will be available. As the lathe comes in kit form there is a considerable saving in price. It is made entirely of cast iron and steel and is a very robust tool.

HECTOR 100E

A British made centre lathe of cast iron and steel construction. It is a stablemate of the Simat 101 but there the similarity ends. Firstly it is a metric machine with a centre height of 50mm and a distance between centres of 300mm. It has a gap bed that allows extra capacity. The spindle runs in sealed ball races making it a very free running machine, improving accuracy and extending its life. While the Simat has a very traditional shape, the Hector is a more modern box-shaped machine. It comes complete with

faceplate and centres. The Simat accessories fit the Hector lathe and the morse tapers are again size '0'. Unlike the Simat it comes complete with a reversible motor and switch. Hand-wheel graduations are in 0.025mm that is near enough 0.001in so that working to imperial measurements is not at all difficult.

Both the Hector and Simat are available from Wexler Machine Tools, Wellspring Farmhouse, Southrepps, Norwich NR11 8XA.

JASON MODEL MAKERS LATHE

A British made lathe with a gap bed. Soundly constructed from cast iron and steel, the centre height is 1.5in with 2in clearance over the gap. The bearings are sealed ballraces for long life and accuracy. Graduations are to 0.001in.

The lathe comes complete with motor; standard accessories include centre and faceplate with drive dog. The saddle can be operated with a self-acting mechanism and change wheels are available to allow screw cutting operation.

There is a wide range of accessories available and these include three and four-jaw chucks, collets, drill chuck, and a vertical slide. A dividing head which uses change wheels to obtain divisions is also available as are steadies, a machine vice and a most useful extra, long cross slide. The latter enables parting operations to be carried out using a rear tool post, and this gives extra rigidity. The spindle nose is threaded and the chucks screw direct on to this, there being no need for an adapter.

The bed of the machine is of a very hefty box-like construction which gives great rigidity and allows heavier work to be carried out than one would normally expect from a lathe of this capacity.

The machine is only available direct from L.C. Jay and Son Ltd, 19 Oak Street, Norwich, NR3 3RQ, who are not only the suppliers but also manufacture it including casting all components.

THE SHERLINE 4000A

The Sherline 4000A is a robust little lathe with a centre height of just over 1.5in. A distance of 8in between centres allows a reasonable size of work to be dealt with. It is built on modern lines with rigid construction. An unusual feature is a swivelling headstock which is used for taper turning. The lathe is supplied complete with a motor, three-jaw chuck, faceplate, drive dog, two centres and a drill chuck. Variable speed control replaces the more usual belt operated system and gives speeds of 100 to 2,750 rpm. The

saddle is operated via a handle that controls the lead screw running up the middle of the solid lathe bed. Somewhat unusual is the fact that power operation of this is via a separate motor.

Having the above arrangement means that normal screwcutting arrangements cannot be used and among the wide range of accessories available for the lathe is a special attachment which enables the operator to screw cut both imperial and metric threads. Other available accessories include a four-jaw chuck, steady, rotating centre, special parting tool holder, a vertical slide/vice and indexing attachment.

A vertical milling column, which bolts to the rear of the machine is available and the normal lathe motor and head are attached to this for milling purposes. Among the accessories available for milling are a collet set, fly cutter and boring head. The latter is an unusual device for these small lathes and can be useful for facing or boring both in the milling machine or the lathe.

A further attachment that increases the capacity of the lathe is a set of spacer blocks. This raises the height of the mandrel and tailstock giving an increase of about 1in in capacity. All handwheels are of a nice large size and all have clear graduations for imperial measurements, but a metric version can be obtained if required. These measurements are to 0.001in or 0.01mm.

The lathe is available from Merthyr Machines International, 1 Thornbury Close, Castle View, Merthyr Tydfil, Mid Glamorgan CF48 1HP.

APPENDIX 1

CHARTS

Cutting Speeds in RPM Metric Sizes

DIA. OF MATERIAL OR DRILL	GAUGE PLATE — HIGH CARBON STEEL	MONEL METAL — CAST IRON — STEEL — STAINLESS STEEL	BRASS — BRONZE — FREE CUTTING MILD STEEL	ALUMINIUM — MAZAK
1.0	970	3878	9695	14542
1.5	647	2589	6474	9711
2.0	485	1941	4853	7280
2.5	388	1552	3882	5823
3.0	323	1294	3234	4851
3.5	277	1108	2772	4158
4.0	243	970	2425	3638
5.0	194	776	1941	2911
6.0	162	647	1617	2426
7.0	139	554	1386	2079
8.0	121	485	1213	1819
9.0	108	431	1078	1617
10.0	97	388	970	1455
11.0	88	353	882	1323
12.0	81	323	809	1213
14.0	69	277	693	1039
16.0	61	243	607	910
18.0	54	216	539	808
20.0	49	194	485	728
22.0	44	176	441	662
26.0	37	149	373	560
30.0	32	129	324	485
34.0	29	114	285	428
38.0	26	102	255	383
42.0	23	93	231	347
46.0	21	85	211	317
50.0	19	78	194	291
56.0	17	70	173	260
62.0	16	62	156	234
68.0	14	56	141	211
74.0	13	52	130	195
80.0	12	49	121	182
89.0	11	44	109	163
95.0	10	41	102	153
100.0	9.7	39	97	145

Cutting Speeds in RPM Imperial Sizes

DIA. OF MATERIAL OR DRILL	GAUGE PLATE — HIGH CARBON STEEL	MONEL METAL — CAST IRON — STEEL — STAINLESS STEEL	BRASS — BRONZE — FREE CUTTING MILD STEEL	ALUMINIUM — MAZAK
1/16	611	2445	6112	9168
5/64	489	1955	4888	7332
3/32	408	1630	4075	6113
7/64	349	1379	3492	5238
1/8	306	1222	3056	4584
9/64	272	1086	2716	4074
5/32	244	978	2444	3666
11/64	222	889	2222	3333
3/16	204	815	2038	3057
13/64	188	752	1880	2820
7/32	175	698	1746	2619
15/64	163	652	1629	2444
1/4	153	611	1528	2292
5/16	122	489	1222	1833
3/8	102	407	1018	1527
7/16	87	349	873	1309
1/2	76	306	764	1146
9/16	68	272	679	1019
5/8	61	244	611	916
3/4	51	204	509	764
7/8	44	174	436	654
1	38	153	382	573
1, 1/8	34	136	339	509
1, 1/4	31	122	306	459
1, 3/8	28	111	278	417
1, 1/2	25	102	254	381
1, 3/4	22	87	218	327
2	19	76	191	286
2, 1/4	17	68	169	253
2, 1/2	15	61	153	229
2, 3/4	14	56	139	209
3	13	51	127	191
3, 1/4	12	47	117	176
3, 1/2	11	44	109	164
3, 3/4	10	41	102	153
4	9.5	38	95	143

DETAILS OF THREADS INCLUDING DRILL SIZES FOR TAPPING AND CLEARANCE

I.S.O. Metric Coarse 60°

nom. dia. mm	pitch mm	basic major diameter mm	basic effective diameter mm	basic minor diameter of external threads mm	basic minor diameter of internal threads mm	recommended tapping drill size mm	clearance drill size mm
1	0.25	1.000	0.838	0.693	0.729	0.75	1.05
1.1	0.25	1.100	0.938	0.793	0.829	0.85	1.15
1.2	0.25	1.200	1.038	0.893	0.929	0.95	1.25
1.4	0.30	1.400	1.205	1.032	1.075	1.10	1.45
1.6	0.35	1.600	1.373	1.170	1.221	1.25	1.65
1.8	0.35	1.800	1.573	1.370	1.421	1.45	1.85
2	0.40	2.000	1.740	1.509	1.567	1.60	2.05
2.2	0.45	2.200	1.908	1.648	1.713	1.75	2.25
2.5	0.45	2.500	2.208	1.948	2.013	2.05	2.60
3	0.50	3.000	2.675	2.387	2.459	2.50	3.10
3.5	0.60	3.500	3.110	2.764	2.850	2.90	3.60
4	0.70	4.000	3.545	3.141	3.242	3.30	4.10
4.5	0.75	4.500	4.013	3.580	3.688	3.70	4.60
5	0.80	5.000	4.480	4.019	4.134	4.20	5.10
6	1.00	6.000	5.350	4.773	4.917	5.00	6.10
7	1.00	7.000	6.350	5.773	5.917	6.00	7.20
8	1.25	8.000	7.188	6.466	6.647	6.80	8.20
9	1.25	9.000	8.188	7.466	7.647	7.80	9.20
10	1.50	10.000	9.026	8.160	8.376	8.50	10.20
11	1.50	11.900	10.026	9.160	9.376	9.50	11.20
12	1.75	12.000	10.836	9.853	10.106	10.20	12.20
14	2.00	14.000	12.701	11.546	11.835	12.00	14.25
16	2.00	16.000	14.701	13.546	13.835	14.00	16.25
18	2.50	18.000	16.376	14.933	15.294	15.50	18.25
20	2.50	20.000	18.376	16.933	17.294	17.50	20.25
22	2.50	22.000	20.376	18.933	19.294	19.50	22.25
24	3.00	24.000	22.051	20.319	20.752	21.00	24.25

I.S.O. Metric Fine 60°

nom. dia. mm	pitch mm	basic major diameter mm	basic effective diameter mm	basic minor diameter of external threads mm	basic minor diameter of internal threads mm	recommended tapping drill size mm	clearance drill size mm
1·7	0·35	1·70	1·473	1·270	1·321	1·35	1·80
2·0	0·45	2·00	1·708	1·448	1·513	1·55	2·10
2·3	0·40	2·30	2·040	1·809	1·867	1·90	2·40
2·6	0·45	2·60	2·308	2·048	2·113	2·15	2·70
3·0	0·35	3·00	2·773	2·570	2·621	2·65	3·10
3·0	0·60	3·00	2·610	2·264	2·350	2·40	3·10
4·0	0·50	4·00	3·675	3·387	3·459	3·50	4·10
4·0	0·75	4·00	3·513	3·080	3·188	3·20	4·10
5·0	0·50	5·00	4·675	4·387	4·459	4·50	5·10
5·0	0·90	5·00	4·415	3·896	4·026	4·10	5·10
5·5	0·90	5·50	4·915	4·396	4·526	4·60	5·60
6·0	0·75	6·00	5·513	5·080	5·188	5·20	6·10
8·0	0·75	8·00	7·513	7·080	7·188	7·20	8·20
8·0	1·00	8·00	7·350	6·773	6·917	7·00	8·20
9·0	1·00	9·00	8·350	7·773	7·917	8·00	9·20
10·0	0·75	10·00	9·513	9·080	9·188	9·20	10·20
10·0	1·00†	10·00	9·350	8·773	8·917	9·00	10·20
10·0	1·25	10·00	9·188	8·466	8·647	8·80	10·20
12·0	1·00	12·00	11·350	10·773	10·917	11·00	12·20
12·0	1·25†	12·00	11·188	10·466	10·647	10·80	12·20
12·0	1·50	12·00	11·026	10·160	10·376	10·50	12·20
14·0	1·25†	14·00	13·188	12·466	12·647	12·80	14·25
14·0	1·50	14·00	13·026	12·160	12·376	12·50	14·25
16·0	1·00	16·00	15·350	14·773	14·917	15·00	16·25
16·0	1·50*	16·00	15·026	14·160	14·376	14·50	16·25
18·0	1·50†	18·00	17·026	16·160	16·376	16·50	18·25
20·0	1·00	20·00	19·350	18·773	18·917	19·00	20·25
20·0	1·50*	20·00	19·026	18·160	18·376	18·50	20·25
20·0	2·00	20·00	10·701	17·546	17·835	18·00	20·25
22·0	1·50	22·00	21·026	20·160	20·376	20·50	22·25
24·0	1·00	24·00	23·350	22·773	22·917	23·00	24·25
24·0	1·50	24·00	23·026	22·160	22·376	22·50	24·25
24·0	2·00	24·00	22·701	21·546	21·835	22·00	24·25
25·0	1·50*	25·00	24·026	23·160	23·376	23·50	25·25

Model Engineers Threads – 55°

Diameter	Threads per inch	Core	Tapping Drill mm
1/8	40	0.0930	2.55
5/32	40	0.1242	3.25
3/16	40	0.1555	4.00
7/32	40	0.1867	4.80
1/4	40	0.2187	5.50
5/16	40	0.3093	7.10
3/8	40	0.3718	8.70
7/16	40	0.4343	10.30
1/2	40	0.4680	11.90
1/4	32	0.2100	5.50
5/16	32	0.3085	7.00
3/8	32	0.3350	8.70
7/16	32	0.3975	10.30
1/2	32	0.4600	11.90
1/8	26	0.0758	2.45
3/16	26	0.1383	3.65
1/4	26	0.2007	5.15
5/16	26	0.2633	6.90
3/8	26	0.3258	8.40
7/16	26	0.3883	9.92
1/2	26	0.4508	11.50
5/8	26	0.5758	14.50

British Association (BA) 47 1/2°

BAND	PITCH	DIA	CORE	TAPPING DRILL	CLEARANCE DRILL
0	0 ·0394	0 ·2362	0 ·1890	5.10	6.10
1	0 ·0354	0 ·2087	0 ·1661	4.50	5.40
2	0 ·0319	0 ·1850	0 ·1468	4.00	4.80
3	0 ·0287	0 ·1614	0 ·1268	3.40	4.20
4	0 ·0260	0 ·1417	0 ·1106	3.00	3.70
5	0 ·0232	0 ·1260	0 ·0980	2.65	3.30
6	0 ·0209	0 ·1102	0 ·0850	2.30	2.90
7	0 ·0189	0 ·0984	0 ·0756	2.05	2.60
8	0 ·0169	0 ·0866	0 ·0661	1.80	2.25
9	0 ·0154	0 ·0748	0 ·0563	1.55	1.95
10	0 ·0138	0 ·0669	0 ·0504	1.40	1.75
11	0 ·0122	0 ·0591	0 ·0445	1.20	1.60
12	0 ·0110	0 ·0512	0 ·0378	1.05	1.40
13	0 ·0098	0 ·0472	0 ·0354	0.98	1.30
14	0 ·0091	0 ·0394	0 ·0283	0.80	1.10
15	0 ·0083	0 ·0354	0 ·0256	0.70	0.98
16	0 ·0075	0 ·0311	0 ·0220	0.60	0.88

Lengths of Chords for Spacing Circle whose Diameter is 1. For Circles of other Diameters Multiply Length given in Table by Diameter of Circle

No. of Spaces	Length of Chord	No. of Spaces	Length of Chord	No. of Spaces	Length of Chord
3	·8660	36	·0872	69	·0455
4	·7071	37	·0848	70	·0449
5	·5878	38	·0826	71	·0442
6	·5000	39	·0805	72	·0436
7	·4339	40	·0785	73	·0430
8	·3827	41	·0765	74	·0424
9	·3420	42	·0747	75	·0419
10	·3090	43	·0730	76	·0413
11	·2817	44	·0713	77	·0408
12	·2588	45	·0698	78	·0403
13	·2393	46	·0682	79	·0398
14	·2225	47	·0668	80	·0393
15	·2079	48	·0654	81	·0388
16	·1951	49	·0641	82	·0383
17	·1838	50	·0628	83	·0378
18	·1736	51	·0616	84	·0374
19	·1646	52	·0604	85	·0370
20	·1564	53	·0592	86	·0365
21	·1490	54	·0581	87	·0361
22	·1423	55	·0571	88	·0357
23	·1362	56	·0561	89	·0353
24	·1305	57	·0551	90	·0349
25	·1253	58	·0541	91	·0345
26	·1205	59	·0532	92	·0341
27	·1161	60	·0523	93	·0338
28	·1120	61	·0515	94	·0334
29	·1081	62	·0507	95	·0331
30	·1045	63	·0499	96	·0327
31	·1012	64	·0491	97	·0324
32	·0980	65	·0483	98	·0321
33	·0951	66	·0476	99	·0317
34	·0923	67	·0469	100	·0314
35	·0896	68	·0462		

APPENDIX 2

DECIMAL EQUIVALENTS

In the past some drills for use in Great Britain were designated by numbers and letters. These have now been replaced by metric versions. The chart shows details of all drills, fraction no. (gauge) and metric giving the equivalents.

Table showing imperial fraction, metric, English drill gauge and imperia decimal equivalents.

Frac.	mm.	Gauge	Inch
	·32		·0126
	·343	80	·0135
	·35		·0138
	·368	79	·0145
	·38		·0150
$\frac{1}{64}$	·397		·0156
	·4		·0157
	·406	78	·0160
	·42		·0165
	·45		·0177
	·457	77	·0180
	·48		·0189
	·5		·0197
	·508	76	·0200
	·52		·0205
	·533	75	·0210
	·55		·0217
	·572	74	·0225
	·58		·0228
	·6		·0236
	·610	73	·0240
	·62		·0244
	·635	72	·0250
	·65		·0256
	·660	71	·0260
	·68		·0268
	·7		·0276
	·711	70	·0280
	·72		·0283
	·742	69	·0292
	·75		·0295
	·78		·0307
	·787	68	·0310
$\frac{1}{32}$	·794		·0312
	·8		·0315
	·813	67	·0320
	·82		·0323
	·838	66	·0330
	·85		·0335
	·88		·0346
	·889	65	·0350
	·9		·0354
	·914	64	·0360
	·92		·0362
	·940	63	·0370
	·95		·0374
	·965	62	·0380
	·98		·0386
	·991	61	·0390
	1·00		·0394
	1·016	60	·0400
	1·041	59	·0410
	1·05		·0413
	1·067	58	·0420

Frac.	mm.	Gauge	Inch
	1·092	57	·0430
	1·1		·0433
	1·15		·0453
	1·181	56	·0465
$\frac{3}{64}$	1·191		·0469
	1·2		·0472
	1·25		·0492
	1·3		·0512
	1·321	55	·0520
	1·35		·0531
	1·397	54	·0550
	1·4		·0551
	1·45		·0571
	1·5		·0591
	1·511	53	·0595
	1·55		·0610
$\frac{1}{16}$	1·588		·0625
	1·6		·0630
	1·613	52	·0635
	1·65		·0650
	1·7		·0669
	1·702	51	·0670
	1·75		·0689
	1·778	50	·0700
	1·8		·0709
	1·85		·0728
	1·854	49	·0730
	1·9		·0748
	1·930	48	·0760
	1·95		·0768
$\frac{5}{64}$	1·984		·0781
	1·994	47	·0785
	2·00		·0787
	2·05		·0807
	2·057	46	·0810
	2·083	45	·0820
	2·1		·0827
	2·15		·0846
	2·184	44	·0860

Frac.	mm.	Gauge	Inch
	2·2		·0866
	2·25		·0886
	2·261	43	·0890
	2·3		·0906
	2·35		·0925
	2·375	42	·0935
$\frac{3}{32}$	2·381		·0938
	2·4		·0945
	2·438	41	·0960
	2·45		·0965
	2·489	40	·0980
	2·5		·0984
	2·527	39	·0995
	2·55		·1004
	2·578	38	·1015
	2·6		·1024
	2·642	37	·1040
	2·65		·1043
	2·7		·1063
	2·705	36	·1065
	2·75		·1083
$\frac{7}{64}$	2·778		·1094
	2·794	35	·1100
	2·8		·1102
	2·819	34	·1110
	2·85		·1122
	2·870	33	·1130
	2·9		·1142
	2·946	32	·1160
	2·95		·1161
	3·00		·1181
	3·048	31	·1200
	3·1		1220
$\frac{1}{8}$	3·175		·1250
	3·2		·1260
	3·25		·1280
	3·264	30	·1285
	3·3		·1299
	3·4		·1339

Frac.	mm.	Gauge	Inch
	3·454	29	·1360
	3·5		·1378
	3·569	28	·1405
9/64	3·572		·1406
	3·6		·1417
	3·658	27	·1440
	3·7		·1457
	3·734	26	·1470
	3·75		·1476
	3·797	25	·1495
	3·8		·1496
	3·861	24	·1520
	3·9		·1535
	3·912	23	·1540
5/32	3·969		·1562
	3·988	22	·1570
	4·00		·1575
	4·039	21	·1590
	4·089	20	·1610
	4·1		·1614
	4·2		·1654
	4·216	19	·1660
	4·25		·1673
	4·3		·1693
	4·305	18	·1695
11/64	4·366		·1719
	4·394	17	·1730
	4·4		·1732
	4·496	16	·1770
	4·5		·1772
	4·572	15	·1800
	4·6		·1811
	4·623	14	·1820
	4·7	13	·1850
	4·75		·1870
3/16	4·762		·1875
	4·8	12	·1890
	4·851	11	·1910

Frac.	mm.	Gauge	Inch
	4·9		·1929
	4·915	10	·1935
	4·978	9	·1960
	5·00		·1969
	5·055	8	·1990
	5·1		·2008
	5·105	7	·2010
13/64	5·159		·2031
	5·182	6	·2040
	5·2		·2047
	5·220	5	·2055
	5·25		·2067
	5·3		·2087
	5·309	4	·2090
	5·4		·2126
	5·410	3	·2130
	5·5		·2165
7/32	5·556		·2188
	5·6		·2205
	5·613	2	·2210
	5·7		·2244
	5·75		·2264
	5·791	1	·2280
	5·8		·2283
	5·9		·2323

Frac.	mm.	Letter	Inch
	5·944	A	·2340
15/64	5·953		·2344
	6·00		·2362
	6·045	B	·2380
	6·1		·2402
	6·147	C	·2420
	6·2		·2441
	6·248	D	·2460
	6·25		·2461
	6·3		·2480

Frac.	mm.	Letter	Inch
1/4	6·350	E	·2500
	6·4		·2520
	6·5		·2559
	6·528	F	·2570
	6·6		·2598
	6·629	G	·2610
	6·7		·2638
17/64	6·747		·2656
	6·75		·2657
	6·756	H	·2660
	6·8		·2677
	6·9		·2717
	6·909	I	·2720
	7·00		·2756
	7·036	J	·2770
	7·1		·2795
	7·137	K	·2810
9/32	7·144		·2812
	7·2		·2835
	7·25		·2854
	7·3		·2874
	7·366	L	·2900
	7·4		·2913
	7·493	M	·2950
	7·5		·2953
19/64	7·541		·2969
	7·6		·2992
	7·671	N	·3020
	7·7		·3031
	7·75		·3051
	7·8		·3071
	7·9		·3110
5/16	7·938		·3125
	8·00		·3150
	8·026	O	·3160
	8·1		·3189
	8·2		·3228
	8·204	P	·3230

Frac.	mm.	Letter	Inch
	8·25		·3248
	8·3		·3268
21/64	8·334		·3281
	8·4		·3307
	8·433	Q	·3320
	8·5		·3346
	8·6		·3386
	8·611	R	·3390
	8·7		·3425
11/32	8·731		·3438
	8·75		·3445
	8·8		·3465
	8·839	S	·3460
	8·9		·3504
	9·00		·3543
	9·093	T	·3580
	9·1		·3583
23/64	9·128		·3594
	9·2		·3622
	9·25		·3642
	9·3		·3661
	9·347	U	·3680
	9·4		·3701
	9·5		·3740
3/8	9·525		·3750
	9·576	V	·3770
	9·6		·3780
	9·7		·3819
	9·75		·3839
	9·8		·3858
	9·804	W	·3860
	9·9		·3898
25/64	9·922		·3906
	10·00		·3937
	10·084	X	·3970
	10·1		·3976
	10·2		·4016
	10·25		·4035

Frac.	mm.	Letter	Inch
	10·262	Y	·4040
	10·3		·4055
13/32	10·319		·4062
	10·4		·4094
	10·490	Z	·4130
	10·5		·4134
	10·6		·4173
	10·7		·4213
27/64	10·716		·4219
	10·75		·4232
	10·8		·4252
	10·9		·4291
	11·00		·4331
	11·1		·4370
7/16	11·112		·4375
	11·2		·4409
	11·25		·4429
	11·3		·4449
	11·4		·4488
	11·5		·4528

Frac.	mm.	Letter	Inch
29/64	11·509		·4531
	11·6		·4567
	11·7		·4606
	11·75		·4626
	11·8		·4646
	11·9		·4685
15/32	11·906		·4688
	12·00		·4724
	12·1		·4764
	12·2		·4803
	12·25		·4823
	12·3		·4843
31/64	12·303		·4844
	12·4		·4882
	12·5		·4921
	12·6		·4961
1/2	12·7		·5000
	12·75		·5020
	12·8		·5039
	12·9		·5079
	13·00		·5118

APPENDIX 3
GLOSSARY OF TERMS

Many of the terms used in engineering, and in particular in lathe work, are strange to those who have no knowledge of such things. From past experience I know that many people who are not experienced do not like to ask the meaning of a phrase which they have seen in a book, or indeed they may not know anyone with suitable knowledge to whom they can turn. I am therefore including many such words and phrases in a separate section. All or nearly all have been mentioned at various stages throughout the text. I feel however it is far easier for readers to be able to refer to this section for a full understanding of such terms.

Allen Key An allen key is the name given to a short length of hexagon-shaped bar. These days such keys are a fairly common item as many DIY tools require them. They are used for tightening or loosening special screws made with a recess to accept the key. Usually the key is bent to an 'L' shape giving a short and long end. It is possible, however, to purchase straight keys with handles of various types. Many model makers make handles for the normal type of allen key. Most compact lathes need the use of such keys for nearly all adjustments to the component parts. Allen keys come in metric and imperial sizes.

Apron This is how the saddle of a lathe is sometimes referred to. The name comes from larger lathes which have a cover rather like an apron in the front of the saddle to protect the lead screw.

Arbor The dictionary describes an arbor as the spindle or axle of a wheel. In relation to a lathe, however, it is usually used to describe the main spindle. It can also be used for the spindle of the tailstock sometimes, even though this does not revolve. If a milling attachment is used then the spindle of that can also be described as an arbor. Possibly even more important still is the

way the word is used to describe a round bar for mounting tools, a typical use coming to mind being when mounting a slitting saw. Arbors can also be used for test purposes. When a specially ground bar centred at each end is set up to check the lathe alignment.

Back Gear This is a feature found on some lathes. It consists of gears which can be engaged and will allow a much lower speed than normal to be used. Some compact lathes have a belt system operating in the same way.

Backlash All moving parts of any machine are subject to backlash in some form or another. If we take two gears meshing together, no matter how well they have been made there will be some slight movement before the drive of the machine is taken up. Similarly, where a belt is concerned, slackness will cause some slight tightening before there is any movement of the driven component. Possibly however this type of backlash is of less concern to the home machinist than the looseness that can be felt on the handles of the lathe saddle, top slide, tailstock etc. This looseness is backlash, and the handle of these components will move a little before the actual part itself travels. This is easily felt by the operator. Mostly it will have little effect on our work but if it is necessary for cutting tools to be withdrawn and then replaced in exactly the same position, the backlash can cause loss of accuracy. It is essential to know how much backlash is on each component and to allow for this on the handle. The amount can be checked quite easily with a clock gauge held against the component in use and noting the handle travel before the part, eg the saddle or tailstock actually moves. If a note of the amount can be taken then greater accuracy can be achieved by making allowances for it. As wear takes place so backlash will increase and a check should be kept in order that it may be compensated for where possible.

Bed The bed is the main part of the lathe to which all other components are fixed. Beds are made in various forms, each manufacturer having his own idea on which bed is most suitable for the particular machine. Care must be taken with compact lathes not to twist the lathe bed if the machine is bolted to a bench. Once twisted it will probably retain the twist permanently and the lathe will lose its accuracy.

Boring The word is applied as one would expect to all work involved in making holes in work. However for small diameter holes the word drilling is frequently used and boring reserved for processes where a specially shaped bar is in use as against a drill. The advantage of boring as against drilling is that greater accuracy can be achieved. Usually during the process the work is held on the lathe mandrel in some way and the boring bar held in the tool post. There are instances however where the boring bar can be held in the tailstock, particularly in the case of repetition work.

Boring Bars Boring bars are specially designed tools for, as the name suggests, boring holes. They can be made or purchased in various forms but for the compact lathe the usual type is made in one piece. For larger diameter bores however there is much to be said for making bars with separate tool bits in order that a thicker bar may be used.

Boring Between Centres Although most work is held on the mandrel for the purpose of boring, sometimes this is not practical because the work is far too heavy for such purposes. In these cases it can be held with clamps to the saddle and a boring bar held between lathe centres. The lathe is set in motion and the table traversed to carry out the work.

Boring Head An adjustable boring bar which can be used either in the lathe or the milling machine. A micro-adjustable screw allows the boring tool to be used to much finer limits than would be expected with a normal boring bar. The tool can also be used for facing large diameter work rather in the way a fly cutter operates and for this reason is sometimes called a boring and facing head.

Carrier When work is mounted between centres for turning operations the carrier is used as a means of driving it. Various manufacturers make different versions of these simple devices but basically all consist of a clamp which is secured to the work and which is driven from the faceplate.

Centres This word is used to cover a whole range of meanings. The name is used to describe the main measurement of a lathe such as centre height. When work is marked out prior to machining the centres are often marked to allow the work to be

mounted accurately on the lathe. A small indentation in the work is made for the purpose and this indentation is described as the centre. Small, pointed pieces of round bar held in either the mandrel or the tailstock are also described as centres. These are, of course, when in position at exactly centre height. Two types of plain centre are made. The soft centre is used in the headstock and this should revolve at the same speed as the work and so there should be no wear on it. Hard centres are used in the tailstock and remain stationary while the work which is supported on them revolves. It is for this reason that they are hardened in order to reduce wear. It is essential that all tailstock centres be well lubricated at the point where they enter the work to prevent a build-up of heat which will cause wear on the centre as well as the distinct danger of a seize-up caused through the welding action of the heat. A thick grease is recommended for the lubrication, the best of all lubricants being tallow. It is possible to get tungsten tipped centres which are also hard and wear probably a little better than the normal hard type. All centres will show signs of wear after a period of time and must be replaced when they do so in order to prevent a loss of accuracy. It is also possible to obtain revolving centres. These are specially designed free running centres designed to revolve with the work when held in the tailstock. They are somewhat expensive but certainly save wear. They also have the advantage that cutting speeds can be increased with their use.

Centre Drill Sometimes referred to as a Slocombe Drill this tool is essential for starting holes in order to achieve accuracy. This applies both to work being drilled as part of lathe operations as well as work mounted on a drill/mill attachment for drilling purposes. Sometimes it is necessary to pass a hole through two parts of a component and, in these cases, if a drill is used for the second hole it will almost certainly wander off line. To prevent this, small centre drills can be fitted into bars of metal to extend their length. Centre drills come in a variety of sizes both imperial and metric.

Centre Height The height above the lathe bed of the mandrel centre.

Change Wheels Not all compact lathes have change wheels but if they are available they make for highly flexible working. If the mandrel of the lathe is connected to the saddle lead screw with

gears then this allows automatic travel of the saddle, and this automatic travel will be far smoother than could possibly be achieved with hand operation. The train of gears used for the purpose is worked out in such a way that the finest feed possible can be achieved. If this gear train is altered to another ratio then the travel of the saddle and hence the tool will alter. In fact by careful gear selection we can make the travel such that it will be in any relationship to the revolving mandrel that we might wish. The system is used to cut threads and some gears. The extra gear wheels needed to alter the gear train are described as change wheels. Lathe manufacturers invariably supply charts to enable the gear train to be set up to get the travel we require.

Chuck The chuck is a means of holding either work or tools such as drills and taps. The latter type consists of a three-jaw version which is of suitable size for the various tools for which it is designed. The chucks designed for holding work come in several varieties. The most common is the three-jaw self-centering variety and this is, in many ways, similar to the type used for holding tools. It operates on one of two systems known as either lever or geared scroll, all three jaws at once either opening or closing them. It is only suitable for holding round bar or hexagon-shaped material. To hold square bar special adaptors must be made up. It has its limitations and as chucks are never absolutely accurate it should only be used where components are to be turned in such a way that this slight loss of accuracy is overcome. The four-jaw independent chuck has four jaws which work independently of each other and so any reasonable shape of work can be held in it. It has the disadvantage, if it can be called that, of needing to set the work to run true. This is a small price to pay for such versatility and once the art of setting work has been mastered it becomes very easy.

Chuck Key This is the name given to the key used to close chucks. It probably needs little explanation but a word of warning that the correct size of key must be used for the particular chuck.

Clasp Nut Used only on a few compact lathes, a clasp nut is a means of engaging the saddle to the lead screw. It consists of a nut cut to the same thread as the lead screw and then sliced in half. The two halves are held away from the lead screw but by

using a lever can be closed so that it then fits directly on the lead screw and thus makes the saddle travel as required.

Clock Gauge When using a compact lathe the clock gauge is sometimes replaced with a form of indicator, the principle of both being exactly the same. The clock gauge consists of a spring-loaded pointer attached to a dial and this is mounted in some way on the lathe, frequently with a magnetic stand. The pointer is brought into contact with the work and this causes the hand on the gauge to move. As the work is rotated the hand moves according to the position of the work and adjustments can be made to get the work lined up absolutely accurately on centre. Small indicators to do a similar job can be made up at home and are capable of being just as accurate as an expensive clock gauge.

Compound Slide Another name for the top slide, so called because it is swivelling and allows compound angles to be set up.

Countershaft A shaft placed between the motor and the lathe pulleys and containing a separate range of pulleys. This allows the number of speeds available with a lathe to be increased, it also makes the lathe smoother running as it takes up the vibration from the motor.

Cyanoacrylic Adhesive Commonly called super glue but available in a variety of forms. Some of these are suitable for holding components together for marking out and so the adhesive may well be recommended in a text book.

Collets These are a means of holding either work or tools such as milling cutters. They are made in various forms but basically are small tubes which are split to allow them to tighten on whatever is to be held. The closing is caused either by a draw bar or by the tightening of a nose cap.

Counterbore The name is given to either a machining process or a tool, which can be rather confusing to the novice. When applied to the machining process it refers to a hole in the metal through which will go some form of component such as a screw. A further flat bottomed hole allows the head of the bolt or other device to lie flush or below the main component. Although usually used for bolts etc. the process is frequently

used for housing bearings and other components. When applied to a tool it is the name given to one specially designed for counterboring. Such tools can either be purchased or home-made and consist of a pin which is a running fit in the smaller diameter hole and a cutter of suitable diameter for the bolt head etc. Although tools are made specially for the purpose, counterboring can also be carried out on the lathe with the use of boring bars.

Countersink Again a name which can be applied to either a process in metal or to the tool used for that process. Countersinking is similar to counterboring except that the recess is made at an angle, usually either sixty or forty-five degrees. It is a process with which woodworkers are more likely to be familiar as it is used particularly to recess wood screws.

Cross Slide The part of the lathe that can be wound across the bed in order to traverse the tool over the face of the work. The cross slide sometimes has the tool post directly bolted to it or frequently will have a top slide fixed to it which can be twisted at an angle. The top slide is used when milling operations are being carried out on a lathe whether with or without a milling attachment.

Cutting Feed A term applied to all machining operations and denoting the speed at which the cutting tool travels along the work. If the feed is too fast then the work will be uneven and ragged. Most lathes have some means of automatic feeding of the tool and for normal operations the finest possible feed should be set. When hand feeding, care must be taken to ensure that the handle used is wound along as evenly as possible and is not rotated too fast.

Cutting Lubricants These are referred to at length in the main text and are very important for obtaining a good finish. The use of the correct lubricant for the work is very important.

Cutting Speeds This is the speed at which either the work will rotate against the tool or the tool will rotate against the work. It is important that as near the correct speed as possible should be used to get the best work. Cutting speeds are as important when drilling as when turning or milling.

D Bit A tool used to make flat bottomed holes, but because of its method of construction a D bit can also be used to obtain an accurate hole as well. Usually D bits are home-made.

Dial Indicator Another name often applied to a clock gauge.

Diamond Lap A number of minute diamonds set into a base and frequently fitted to a handle. These laps come in a variety of grades and are used for putting a very fine edge on cutting tools.

Die Most dies are rather like a round nut with three holes which connect to the main thread. When run over a piece of metal of the correct diameter the die which is hardened will cut a thread, the metal cut from the grooves being cleared by the three holes referred to above. Most dies are adjustable to allow for a slightly oversize thread to be cut in the first place and then they are adjusted to reduce the thread to the correct size. The process generates considerable heat and so when cutting the appropriate cutting fluid should always be used with dies even when hand held.

Die Stock/Holder The stock or holder is designed to accept dies and comes in two forms. The hand type more normally referred to as the stock, which has the main holder plus a handle either side to allow it to be turned, and the type that goes into the lathe tailstock. Three screws are used to both retain and adjust the die as required.

Depth Gauge A simple device used to measure the depth to which a hole has been drilled or bored. Most depth gauges are home-made and consist of a cross bar with a movable pin and a screw to retain the pin as required. The bar is put on the work with the pin directly over the hole. The screw is released and the pin pushed into the hole until it strikes the bottom. It is then tightened again and withdrawn. The length that protrudes from the bar is the depth of the hole.

Depth of Cut The depth of cut speaks for itself, it being the depth to which the tool penetrates the work before it is traverses along or across it. The term is used whether milling or turning. Too deep a cut will cause the machine to judder and a bad finish to appear on the work at the very least. If the depth is

taken beyond reason the seizing of the machine and possible tool breakage will result. If a great deal of work is to be carried out and the depth of cut is too little then a lot of time will be wasted. A compromise must be found. Depth of cut, cutting speed and cutting feed are all interwoven into good machining techniques and it is a matter of learning how to get all three balanced correctly for the best results.

Dividing Usually the term used when work has to be machined in a number of areas to make a particular shape such as a hexagon or a series of evenly spaced holes or slots. Dividing can either be carried out mechanically or by mathematical means. The former will always be the most accurate.

Dividing Head A somewhat loose term applied to any means of mechanical division. A dividing head can be a simple home-made device using ordinary gear wheels as the means of division, in which case some form of pointer locates in the teeth of a gear wheel and the device can be turned using the pointer to locate in any number of teeth as required. The system is limited by the number of teeth in the gear wheel. For example a sixty-tooth wheel will give divisions of any number which will divide into sixty but will not divide by, say, seven, a different gear wheel being required for this. Some dividing heads work via a worm wheel and a plate with a series of holes. Divisions are obtained by the ratio of the gear plus the number of holes in the plate.

Dividing Plate The plate with a number of holes referred to above for use with a dividing head.

Draw Bar A bar with a short threaded length that passes through the mandrel of either a lathe or milling attachment and locates in collets etc. When tightened it causes the collet to close.

Drilling Attachment An attachment which bolts to the lathe and allows work to be drilled while mounted on the cross slide.

Driving Dog A small bar of metal screwed to the faceplate or a special plate attached to the lathe mandrel. When work is mounted between centres the driving dog locates with the carrier and drives the work round.

End Mill The tool usually used for vertical milling operations which looks rather like a drill with a flattened end and four flutes.

Faceplate A round plate which fixes to the nose of the lathe mandrel and on which work can be mounted. The faceplate has a number of slots, the number depending on the make of lathe, the work is bolted to it through these.

Faceplate Dog The name sometimes given to the driving dog.

Facing While the work is rotating the tool is traversed across it to make the end or face even and possibly machine it to length. The process of taking the tool across the work is called facing.

Filing Rest A small device which is attached to the lathe cross slide and allows a file to be used perfectly horizontally. Some form of height adjustment is necessary to allow the depth of filing to be regulated.

Fine Feed Attachment An attachment which bolts to the drilling attachment to allow a very fine down feed of a milling cutter.

Fly Cutters Single point cutters, frequently home-made. They consist of a body with a cutting tool inserted, the depth of which can be adjusted with a screw. The cutter is rotated slowly on the work and cuts a larger area than is possible with other methods. Using a very slow speed and feed, an exceptionally fine finish can be obtained. The body of the fly cutter may have a shank to fit a milling attachment or it may be made in such a way that it can be fitted directly to the lathe faceplate.

Gap Bed Some lathes have a gap in the bed just in front of the headstock to allow larger work to be turned.

Green Grit A material from which some grinding wheels are made. The substance holding the abrasive is soft and quickly wears away allowing a continual supply of new abrasive material to the surface. Such wheels are therefore highly suitable for grinding very hard materials including tungsten carbide tipped tools.

Grinding Wheels Used on grinding machines for sharpening tools

these are available in a large variety of sizes and grades. If fitting a new one to a grinding machine care must be taken. The maximum speed of rotation is printed on the side of the wheel – this must under no circumstances be exceeded. The paper washers on the wheel must be left there when the wheel is fitted as they are designed to prevent too much pressure being applied to the sides of the wheel when tightening up. A grinding wheel consists of many small grit particles held together with one of a number of adhesives. As the wheel is used so the adhesive wears slowly away and allows fresh sharp grit into position. The rubbing action generates a lot of heat and tools that are being sharpened must be cooled during the process either by dipping in water or by leaving them exposed in cool air for a period of time. The fact that the wheel is made purely of an adhesive and grit means that it has only limited strength. Sharpening therefore must be carried out on the periphery so that the pressure is applied downwards to the strongest part of the wheels. Sharpening on the side of the wheel involves putting stresses on the weakest section with a distinct danger of the wheel breaking up in operation. Safety glasses must be worn when using grinding wheels of any sort.

Grinding Paste Rather like a liquid grindstone, grinding paste consists of small grit particles mixed with some form of lubricant, usually oil. It is used by spreading on a sheet of plate glass and rubbing work on it to get a very fine fit or finish. Grinding paste must be kept well away from all machines as its abrasive nature will quickly wear the bearings of a machine if it comes into contact with them.

Grub Screw A screw without a head which fits totally into the tapped hole for which it is intended. Such screws can have either a slot or hexagon socket as a means of tightening them. Many are hardened in order that they will bite into metal, as they are intended for securing components to each other in a semi-permanent manner. Some have points on the end for the same reason.

Headstock The end of the lathe at which the main chucks and work is held and where the rotating mandrel is.

High Carbon Steel A form of steel which has a high carbon content and therefore is capable of being hardened. Such steel is used

for making tools that are not going to be used all that frequently. Some forms of high carbon steels are sold as silver steel.

High-Speed Steel A form of steel that is very tough having been through several hardening processes before leaving the manufacturer. It is virtually impossible to soften it and it can be ground to make long lasting lathe tools. It is used for making taps, dies and other special tools.

Lead Screws Screw threads which engage in fixed nuts and drive components of machinery. The thread is usually of a square or Acme type. A typical example of a lead screw is the one attached to the handle of a vice and which rotates to close it. Such screws are used to move the saddle, cross slide, and top slide of a lathe as well as the fine down feed of a milling attachment of the adjustable section of a vertical slide.

Live Centre A hardened centre to fit the tailstock of a lathe and on which work will rotate, hence the reason for hardening the material. The name nowadays is often applied to rotating centres also used in the tailstock.

Mandrel Another name for the lathe spindle or any other round bar or arbor used to carry tools etc.

Marking Blue More correctly, marking fluid. Although it is commonly blue other colours can be obtained. It is spread on work and allows scriber marks to show through thus giving a clearer view than if the metal was marked directly.

Milling Attachment A device which bolts to the lathe and carries a rotating head adjustable for height for milling purposes. The name is sometimes rather loosely applied to include vertical slides.

Milling Cutters Any form of cutter designed for milling purposes, this can include cutters for horizontal as well as vertical milling.

Milling Table The movable table of a milling machine. As far as the compact lathe is concerned the term applies to the cross slide when the milling attachment is in place. Some lathes have separate detachable milling tables. The name can also be applied to the table of a vertical slide.

Morse Taper A taper that is extensively used on both headstock and tailstock of lathes. Various sizes of morse taper can be obtained and the size gives indication of both thickness and length. Most compact lathes use either a size '0' or '1'.

Number Drills A system of indicating drill sizes which is now almost completely outdated. Drills were numbered from one to eighty depending on their size and tapping sizes for threads were usually quoted by these numbers. Larger sizes were given letters from A to Z to identify them. Drill numbers are still frequently quoted on drawings and the equivalent metric number may safely be used.

Parting Tool A thin tool designed to be run into the work and cut through it. Modern parting tools are invariably of high-speed steel and fit into special holders.

Rear Tool Post A tool post placed at the rear of the cross slide or the point furthest from the operator. Many compact lathes do not have a big enough cross slide to incorporate such a device, but if there is room then it can be invaluable for parting off.

Reamer A tool used for getting accurate holes. The hole is first drilled slightly undersize and then the reamer passed through.

Roughing This term is applied to the first cuts when turning or milling, as attempts are made to remove as much metal as possible consistent with not damaging, work, tool, or machine. The result is invariably a rough finish which must then be brought to a fine finish with further machining.

Saddle The part of a lathe on which ultimately the tools will be mounted, although further slides may first be added to give extra movement. The saddle moves lengthwise along the lathe bed and the name is given because on larger lathes it actually straddles the bed like a saddle.

Shims Very thin pieces of metal used for packing tools or work to get the correct height.

Slip Stone A small carborundum or similar stone obtainable in various shapes and used for honing the edges of tools after grinding.

Slitting Saw A thin circular saw used for cutting metal and frequently for making small slots or slits. The saws come in a variety of sizes and must be mounted on an arbor before they can be used.

Slocombe Drill More often known as a centre drill and used for starting holes where the extra rigidity of its construction prevents it wandering when striking the metal.

Slot Drill Rather like a flat bottomed drill, the slot drill is a two flute end mill and is particularly useful when cutting slots as, having only two flutes, there is less of a heat build-up than with a conventional end mill. The two flutes also enable swarf to clear at a faster rate.

Socket Screw A round-headed screw, the head having a hexagon insert to allow it to be tightenened with a special key called an allen key. It is a fairly common type of screw on the compact lathe.

Spindle Another name given to the lathe or milling attachment mandrel. The term is frequently used when cutting speeds are to be worked out mathematically.

Stub Drill A drill deliberately manufactured to a shorter length than normal in order to improve rigidity. It is particularly useful when drilling from the tailstock of the compact lathe.

Swarf The residue of metal left after machining operations have been carried out.

Tailstock The part of the lathe furthest from the mandrel and used to align work between centres as well as for holding tools. The tailstock is usually adjustable for length and lockable in position as well as having a sliding mandrel.

Tailstock Chuck A chuck specially designed to fit the tailstock of the lathe to allow drilling operations to be carried out on the work held in the lathe.

Tee Bolts Special flat bottomed bolts designed to fit into tee slots. It is essential that tee bolts always fill these slots completely. If they do not there is a real danger of the casting around the slot breaking away.

Tool Post A pillar which is fitted to the lathe to hold the tool in position while it is in use. Some tool posts carry more than one tool.

Top Slide An adjustable slide that is bolted to the cross slide. It is usually possible to set the top slide at an angle for taper turning operations. Top slides are frequently sold as extras on compact lathes.

Tungsten A very hard wearing material often used these days for making tools. As the material is expensive it is usual to fit it to the tool in the form of a tip. These can either be replaceable having been screwed into position or are sometimes brazed to the tool body. Tungsten can only be sharpened with a green grit grinding wheel and then must be honed with a diamond lap.

Vertical Slide An adaptor that bolts to the lathe cross slide and allows work fixed to it to be raised and lowered. In conjunction with a milling cutter held in the lathe mandrel it converts the lathe to allow complete milling operations to be carried out.

Watchmaker's Tool Post A specially designed tool post for watchmaking lathes which allows complete height adjustment of the tool.

Witness Marks If, for any reason, machining operations have to be ceased and re-started it is virtually impossible to re-set the work back to its original position. The result is that when finished a mark is left showing where the two operations have been started and finished. Such marks are called witness marks.

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